UTILIZATION OF POND SNAIL (*Filopaludina martensi*) AS AN ALTERNATIVE FEED FOR THAI NATIVE CHICKENS

PICHIT WONNAKOM

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE
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ชื่อเรื่อง	การใช้หอยขมเพื่อเป็นอาหารไก่พื้นเมือง
ชื่อผู้เขียน	นายพิชิตร์ วรรณคำ
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บทคัดย่อ

6 การทดลองถูกนำไปใช้ในการประเมินการใช้ประโยชน์ของหอยขม (*Filopaludina martensi*) เพื่อใช้เป็นอาหารสำหรับไก่พื้นเมือง

การทดลองที่ 1 ความหนาแน่นของประชากรของหอยขม (Filopaludina martensi) ในบ่อปล่า (ปลานิล) พบว่า จากบ่อปลา 26 บ่อ ประชากรหอยขมหนาแน่นสูงมาก (226.53±81.44 ตัว/ม^2)

การทดลองที่ 2 ประเมินคุณค่าทางโภชนะของหอยขม ทรีตเมนต์แบ่งเป็น 1. เนื้อหอยขม (ไม่มีเปลือก) 2. หอยขมสุกทั้งตัว 3. หอยขมดิบทั้งตัว สองทรีตเมนต์แรกถูกต้มในน้ำร้อน 2 นาทีและ 20 นาที ตามลำดับ พบว่า เนื้อหอยขมมีโปรตีนรวม (65.58%) และไขมัน (6.31%) สูงกว่าหอยขมต้มสุกและหอยขมดิบทั้งตัวอย่างชัดเจน แต่เนื้อหอยมีเยื่อใย (0.5%) เถ้าและแคลเซียมต่ำกว่าหอยขมสุกและดิบทั้งตัว

การทดลองที่ 3 ทำการหมักหอยสำหรับการเก็บรักษาโดยใช้กากน้ำตาลหรือเกลือ ใช้การทดลองสุ่มอย่างสมบูรณ์ หอยขมที่บดรวมถูกผสมกากน้ำตาลหรือเกลือในถุกพลาสติกสำหรับการหมัก (ขนาด: 8 x 12 นิ้ว) บรรจุหอยขมหมัก 300 กรัม/ถุง บ่มที่อุณหภูมิปกติ คนให้เข้ากัน 2 ครั้งต่อวัน เวลา 8.30 และ 16.30 น. กากน้ำตาลใช้ที่ระดับ 0, 7.5, 10.0, 12.5 และ 15.0% และใช้เกลือที่ระดับ 3.25, 3.79, 4.33, 4.87 และ 5.41%. เนื่องจากค่า pH สีและกลิ่น หอยหมักกากน้ำตาลที่ 15% ดีกว่ากลุ่มอื่นอย่างมีนัยสำคัญ ในวันที่ 1 และ 7 ของการหมัก ($P<0.05$) ช่วงเวลาการหมักหอยขมเหมาะสมที่ 7 วัน แต่ที่ 14 วันทำให้คุณภาพสีและกลิ่นต่ำลง ส่วนการหมักเกลือ พบว่า ทุกระดับและช่วงเวลา ไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ ($P>0.05$) สีและกลิ่น การหมักเกลือที่ 4.8 และ 5.41% ดีกว่ากลุ่มอื่นที่ 7 และ 21 วัน ของการหมัก. อย่างไรก็ตาม การหมักทุกรีตเมนต์ที่ 21 วัน มีค่า pH เพิ่มขึ้นและคุณภาพลงลด ดั้งนั้นช่วงเวลาของการหมักเกลือเหมาะสมที่ 7 -14 วัน

การทดลองที่ 4 ทำการประเมินการย่อยได้โภชนะของหอยขมในอาหาร การแปรรูป (สุกและดิบ) และระดับการใช้ที่ต่างกัน (0, 5, 10 และ 15% ในอาหาร) ไก่พื้นเมืองตัวผู้อายุ 25 สัปดาห์ จำนวน 28 ตัว แบ่งเป็น 7 กลุ่มๆ ละ 4 ซ้ำๆ ละ 1 ตัว ใช้แผนการทดลองแบบสุ่มสมบูรณ์ พบว่า การ

ย่อยได้ของ วัตถุแห้ง (DM) โปรตีนรวม (CP) ไขมัน (EE) และไนโตรเจนฟรีเอ็คแทร็ค (NFE) มีความแตกต่างอย่างไม่มีนัยสำคัญทางสถิติ (P>0.05) การย่อยได้ของเยื่อใย (CF) พบว่า 10% หอยขมดิบสูงสุด แต่ไม่แตกต่าง 0 และ 5% หอยขมดิบ การย่อยได้ของเถ้าสูงสุดที่ 15% ทั้งหอยขมสุกและดิบเมื่อเทียบกับกลุ่มอื่นๆ นอกจากนั้นยังพบว่าที่ 10% หอยสุกมีการย่อยได้แคลเซียม (Ca) สูงสุด เมื่อเทียบกับทรีตเมนต์อื่น ยกเว้นที่ 10% หอยขมดิบ การเสริมหอยขมดิบที่ 5% มีการย่อยได้ฟอสฟอรัส (P) สูงสุด ซึ่งมีนัยสำคัญกับกลุ่มควบคุม 15% หอยขมสุกและดิบ (P<0.05)

การทดลองที่ 5 ทำการประเมินผลของระดับหอยขมสุกป่นในอาหารที่ต่างกันต่อสมรรถภาพการผลิตของไก่พื้นเมืองระยะเล็กและระยะรุ่น โดยอาหารทดลองได้เลือกจากการทดลองที่ 4 ที่มีการย่อยได้ดีที่สุด (CP และ Ca) ลูกไก่คละเพศอายุ 7 วัน 144 ตัว ถูกสุ่มเข้า 6 กลุ่มทดลองๆ 4 ซ้ำๆ ละ 6 ตัว อาหารทดลองใช้หอยขมสุกป่นทดแทนปลาป่นที่ระดับ 0, 25, 50, 75, 100 และ 125% โดยใช้หอยขมป่นที่ระดับ 0, 3.66, 7.39, 10.95, 14.60 และ 18.25% ใช้แผนการทดลองแบบสุ่มสมบูรณ์ พบว่า ไก่พื้นเมืองที่อายุ 1-6 สัปดาห์ เทียบกับทุกกลุ่มทดลอง ไก่ที่ได้รับอาหาร 3.66% หอยป่นมีน้ำหนักตัวที่เพิ่มขึ้น ปริมาณอาหารที่กิน และอัตราการเปลี่ยนอาหารเป็นน้ำหนักตัวที่เพิ่มขึ้น ดีกว่าไก่ที่ได้รับอาหารที่มีหอยป่นระดับสูง (P<0.05) ยกเว้นกลุ่มควบคุม ไก่ที่อายุ 7-16 สัปดาห์ ไก่ที่กินอาหารควบคุม (0% หอยขม) มีน้ำหนักตัวมีชีวิต คุณภาพซาก เช่น เปอร์เซ็นต์ซาก อกนอก อกในและขา ดีกว่ากลุ่มอื่น ยกเว้นไก่ที่ได้รับอาหาร 3.66% หอยป่น (P>0.05)

การทดลองที่ 6 ทำการประเมินผลของระดับหอยขมในอาหารที่ต่างกันต่อสมรรถภาพการผลิตของแม่ไก่พื้นเมือง แม่ไก่สาว 30 ตัว อายุ 25 สัปดาห์ ถูกเลือกและจัดเข้าไปใน 6 กลุ่มทดลองๆ 5 ซ้ำๆ 1 ตัว ใช้แผนการทดลองแบบสุ่มสมบูรณ์ อาหารทดลองใช้หอยขมสุกป่นทดแทนปลาป่นที่ระดับ 0, 25, 50, 75, 100 และ 125% โดยใช้หอยขมป่นที่ระดับ 0, 3.66, 7.39, 10.95, 14.60 และ 18.25% ใช้แผนการทดลองแบบสุ่มสมบูรณ์ พบว่า แม่ไก่พื้นเมืองที่ 26-72 สัปดาห์ ปริมาณอาหารที่กิน น้ำหนักเริ่มการทดลอง น้ำหนักตัวสิ้นสุดการทดลอง และน้ำหนักตัวที่เพิ่มขึ้น ไม่มีความแตกต่างทางสถิติ (P>0.05) แม่ไก่ที่ได้รับอาหารควบคุม (0% หอยขม) มีผลผลิตไข่และอัตราการเปลี่ยนอาหารเป็นน้ำหนักไข่ดีที่สุด แต่ไม่ความแตกต่างอย่างมีนัยสำคัญกับไก่ที่ได้รับแม่ไก่ที่ได้รับอาหาร 3.66 และ 14.060% หอยป่น รูปร่างไข่ ความหนาเยื่อเปลือกไข่ ความแข็งของเปลือกไข่ เปอร์เซ็นต์ไข่ขาวและไข่แดง สัดส่วนไข่แดง สัดส่วนไข่ขาว เปลือกไข่ ฮอกยูนิต (Haugh unit) และแคลเซียมในเปลือกไข่ ไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ (P>0.05) แม่ไก่พื้นเมืองกลุ่มควบคุมมีความสว่างของเปลือกไข่และฟอสฟอรัสในเปลือกไข่สูงกว่ากลุ่มอื่น (P<0.05) ยกเว้น กลุ่ม 3.66% หอยป่น (P>0.05) นอกจากนั้น เราพบว่า สีของไข่แดงของแม่ไก่พื้นเมืองกลุ่มที่ได้รับอาหาร 3.66 หอยป่นดีกว่ากลุ่มอื่น (P<0.05) ยกเว้นแม่ไก่พื้นเมืองที่ได้รับอาหาร 7.39% หอยป่น (P>0.05) นอกจากนั้นเราพบว่า สีของไข่แดงของแม่ไก่พื้นเมืองกลุ่มที่ได้รับอาหาร 3.66 หอยป่น ดีกว่ากลุ่มอื่น (P<0.05)

Title	Utilization of Pond Snail (*Filopaludina martensi*) as an Alternative feed for Thai Native Chickens
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ABSTRACT

Six related experiments were conducted to evaluate the utilization of pond snail (*Filopaludina martensi*) as an alternative feed for Thai native chickens.

In 1st experiment, population density of pond snail (*Filopaludina martensi*) in fish (Nile Tilapia) pond was studied, from 26 ponds it was found that the snail population density was very high density (226.53±81.44 snail/m^2).

The 2nd experiment was conducted to evaluate the nutritive value of pond snail. The treatments included 1. meat snail (without shell), 2. whole snail (cooked) and 3. whole snail (raw). The first two treatments were cooked separately in boiling water for 2 minutes and 20 minutes, respectively. It was found that meat pond snail had the clearly higher CP (65.58%) and EE (6.31%) but had lower CF (0.50%), ash (3.32%) and calcium (2.24%) than cooked and raw whole snail.

The 3rd experiment was conducted to preserve pond snail by fermentation with molasses or salt in completely randomized design. Minced pond snail was thoroughly mixed with molasses or salt in plastic bag for fermentation (size: 8 x 12 inch), 300 g of sample /bag was incubated at ambient temperature and stirred 2 times per day at 8.30 AM and 4.30 PM. The molasses levels were used at 5.0, 7.5, 10.0, 12.5 and 15.0%, and salt levels were used at 3.25, 3.79, 4.33, 4.87 and 5.41%., 15% molasses fermented snail had significant better pH, color and odor than other treatments at 1 and 7 days of fermentation ($P<0.05$). Fermentation with molasses was an appropriate period of 7 days. 14 Days resulted in lower quality of color and odor. With salt fermentation, it was found that the pH of all levels and fermentation

periods were not significant different (P>0.05). 4.87 and 5.41% salt fermented snails had better. Color and odor than other treatments at 7 and 21 days of fermentation. However, all treatments at 21 days of fermentation had their pH increased and hence became bad quality. Fermentation with salt had an appropriate period at 7-14 day.

The 4th experiment was conducted to determine the nutrient digestibility of pond snail in different processing (cooked and raw) and levels (0, 5, 10 and 15% of feed). Twenty-eight Thai native cocks (TNC) aged 25 weeks old, were divided into 7 groups of 4 replications in completely randomized design. It was found that the digestibilities in DM, CP, EE and NFE of pond snail were not significant different (P>0.05). CF digestibility was found the highest in 10% raw pond snails with no difference from 0% and 5% raw snail. It was revealed that the ash digestibility was the highest in 15% pond snail in both processing forms. Moreover the result revealed that 10% cooked snail had the highest Ca digestibility compared to other treatments except 10% raw pond snail. Supplementation of 5% raw pond snail had the highest P digestibility which was significantiy higher than control, 15% cooked or raw pond snails (P<0.05).

The 5th experiment was conducted to evaluate the effect of the levels of cooked pond snail meal in diet on productive performance of starter and grower TNC. The experimental diet was selected from the 4th experiment on the best nutrient digestibility (CP and Ca). At 7 days old, 144 mixed sex chicks were randomly assigned in to six treatments with four replicates of 6 birds each in completely randomized design. The experimental diets were cooked pond snail meal which replaced fish meal as 0, 25, 50, 100 and 125% as follows: 0, 3.66, 7.39, 10.95, 14.60 and 18.25% in the diet. At 1-6 week old TNC were compared in all treatments groups. Chicken fed 3.66% pond snail meal had significant better weight gain, feed intake, feed conversion ratio than chicken fed high levels of pond snail meal (P<0.05), except with control group. At 7-16 week old, the chicken fed control diet (0% pond snail) had better weight gain, feed intake and feed conversion ratio than chicken fed 3.66% pond snail meal (P>0.05). There were linearly decreases in weight gain and increases in FCR as levels of pond snail increased. The carcass quality of

TNC conducted at 15 weeks old was found that chicken fed control (0% pond snail) had significant better live weight and carcass quality such as dressing percentage, pectoralis major, pectoralis minor and thighs than other groups (P<0.05), except chicken fed 3.66% pond snail meal (P>0.05).

The 6th experiment was conducted to evaluate the effects of pond snail meal on productive performance of Thai native hen (TNH). Thirty pullets at 25 weeks-old were selected and assigned into six treatment groups of 5 replication 1 hen each in completely randomized design. The experimental diets were cooked pond snail meal replaced fish meal as 0, 25, 50,100 and 125% as follows: 0, 3.66, 7.39, 10.95, 14.60 and 18.25% in the diet. It was found that TNH at 26-72 weeks old had not differed in feed intake, initial weight, final weight and body weight gain (P>0.05). TNH fed control (0% snail meal) had better egg production and FCR than other groups. There was not significant different from 3.66 and 14.60% snail meal. Shape index, eggshell thickness, shell-breaking strength, albumin and yolk, yolk ration, albumen ration, eggshell, Haugh unit and calcium of eggshell were not significant different (P>0.05). Control TNH had higher bright and phosphorus of eggshell than other groups (P<0.05), except 3.66% snail meal group (P>0.05). Furthermore, it was revealed that yolk color of TNH fed 3.66% snail meal diets was significant better than the others (P<0.05), except TNH fed 7.39 % snail meal (P<0.05).

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Pichit Wonnakom

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CHAPTER 1
INTRODUCTION

Thai indigenous chicken (TIC) or Thai native chicken (TNC) production of Thailand has rapidly improved and is contributing more than 100 million Bath annually to the country's economy. Because Thai people still prefer the TNC meat than the commercial broiler meat especially for preparing the local dishes; however, there is lower supply of the TNC meat in the market and the price is considerably higher than the commercial broiler meat. This deficit supply of TNC meat in the market has escalated the cost in the market. Most Thai farmers prefer TNC to imported exotic breeds, even though TNC has comparatively inferior egg and meat productivity. This is because TNC can survive under very harsh conditions and still reproduce regularly even with minimum care and management (Choprakarn et al., 1998; Klinhom et al., 2005 and Laopaiboon, 1990).

As a result of the technological development and implementation of knowledge to use in the native or native-crossbred chicken farming industries more effectively, new intervention on the improvement and the correction on the short fall of the native or native-crossed chicken has become a challenge.

To be sustainable and more competitive for the native and native- crossbred chicken industry, lowering the production cost should be a priority. This can be achieved either through the breed improvement or by lowering the production cost through innovative feeding management. Since the feed cost used in poultry production are as high as 60-70% of the total cost of production. Therefore, for the improvement in productivity of the present population of native and native-crossbred chicken production, finding new potential feed resources and improvement of feeding strategy is a challenge. Furthermore, in poultry meat production, the price and quality of raw materials used as main protein source in the feed formulation is very important. Although fish meal has been established as the best protein source in the poultry feeds. However, using more proportion of fish meal in the ration were increase the cost of the poultry feed ration.

There is an increasing demand on fish meal for animal production in the world. The amount of fish meal currently used in the world for production of livestocks is about 6-8 million tons/year. Currently, Thailand is using about 0.45 to 0.6 million tons /year of fish meals, which is lower than the demand from livestocks and poultry production industry. There is also another problem arising from high demand of fish meal from animal production industry through illegal fishing and the overfishing which have been indicated as having high impacts on the human food supply.

To find out the alternative of protein sources, quantity, quality and prices are the key determinants. In the aquaculture of fresh water fish in many areas in Thailand, the pond has been heavily infested with the unwanted pond snail (*Filopaludina martensi*), especially in the mixed system of swine farm with the fish culture in Chiang Rai province. After harvesting the fish and running the water out from the pond, huge amounts of pond snail have been found on the bottom of the dry pond (Figure 1). Since this pond snails had been fed on pig manure, the local people considered to be dirty for human food. Therefore, these pond snails have been abandoned and later got rotten and have become a pollution problem for the new round of raising fishes. However, some of the local farmers take this as an opportunity to harvest the pond snail to directly feed their backyard chicken or to mix into a simple ration for feeding to their local or mixed breed chickens.

This study was carried out to investigate the potential of the pond snails using to replace fish meal in the feeds for the production of Thai native chickens raised for meat purpose. Besides reduction in the production cost of TNC meat, it also solved the pollution problem of the pond created by the decaying of the pond snails in the pond.

Figure 1 Pond snail in (Nile tilapia) pond

Objectives of the study

1. To explore the density of the population of pond snails in fish (Nile tilapia) pond culture.

2. To determine the nutritive values and the digestibility of pond snails used as native chicken feeds.

3. To explore the production performances, carcass quality and egg quality of native chicken fed with feed dietary containing different levels of dried grinded pond snails.

Scope and limitation of the study

1. To explore the density of pond snails' population in the fish ponds (Nile Tilapia) of Planil aquaculture group in Phan District, Chiang Rai province.

2. To determine the proximate analysis for the chemical composition of pond snails.

3. To explore on the suitable physical forms, preservation methods and the keeping quality of the pond snails used in the chicken feed.

4. To formulate the feeding trial using different levels of pond snails to replace fishmeal in the native chickens dietary on the productive performance, carcass quality and egg quality of the native chicken raised in Thai conventional way.

Expected knowledge from the study

1. The information on the population of the pond snails infested the fish farms.

2. The information on the nutritive value of pond snails to be used as chicken feeds.

3. The information on the suitable physical forms, preservation methods and the keeping quality of the pond snails used in the chicken feeds.

4. The strategic feeding method on utilization of pond snails as a protein source in the dietary for production of native chicken for meat.

Conceptual frame work of dissertation

Food safety and pollution control are the important keywords for agriculture nowadays. The pollution from the infestation of pond snails in fresh water aquaculture of Nile Tilapia in the north of Thailand is worth in itself for the seeking of the solution. To overcome that pollution problem by finding the way to dispose the pond snails as chicken feed will reward to at least the fish farmers and the chicken production operators.

The investigation to assess the appropriate level of pond snails replacement to the fishmeal in native chicken feed will generate the important information as a guideline for the local farmers to increase the productivity of their native chicken meat production by lowering the feed cost.

CHAPTER 2
LITERATURE REVIEW

Management systems of Thai native chicken production

Thailand is situated in the mainland Southeast Asia, lying between 5° to 20° north and 97° to 105° east with the country's area of 514,000 km^2; about 70 percent of which is used for agriculture. The climate is tropical with relatively high temperatures (24–36 °C) and high humidity (66–83 percent). The population is 65 million; with an average of 5 people per household. Nearly 6 million households, mostly smallholders, are in the rural areas that traditionally possess native chickens (Choprakarn, 2007).

Thai native chicken is reared by farmers mostly for family consumption but they rear for cock fighting and other purposes. If they have excess chicken on the farm, the farmer may sell in form of live chicken or prepare chicken curry or grilled chicken in the village. When the TNC is sold to traders, they say Thai people like TNC because it has better taste compared to commercial broiler chicken. However, the price is 25-30% higher than broiler. TNC is important for the rural development and native breeds of chicken can be found everywhere in Thailand as it can be reared with less investment, they can scavenge their own feed. Furthermore, better survival rate is achieved better in TNC than broiler and can live and hatch naturally without human interferences. Integrated farming system in Thailand has been a tradition and has been known to them and by doing that they can generate more income from different source of farming and animals. It is appropriate for the farmers in the countryside to rear TNC as it does not have adverse effect to ecosystems. This type of farming can sustain for longer period with good return from less investment. Chicken disease like newcastle disease, avain Influenza, fowl chlorea and so on are the diseases of concern to be look into however with the farmers' and knowledge on vaccination and immunization can bring down the mortality of TNC. The low yield compared to commercial chicken can be enhanced or improve by cross breeding with improve breed especially in improving the meat texture. TNC can be considered as the pride of the country or an origin of existence and should be proud to say to the rest of world that, it is our native bird and does not have marketing problem.

Thai indigenous chickens (Gallus gallus domesticus) have been Thai people's way of life at least since the time of the Ayutthaya Kingdom some 400 years ago (Choprakarn, 1976). This can easily be seen throughout the country. TNC are a source of food protein and quick cash income; they are used in leisure pursuits and as offerings in various ritual and ceremonies. They also play an important role as consumers or yard cleaners in the rural area ecosystem by converting leftovers and agricultural by-produce into meat. These roles make TNC a unique part of the everyday lives of the Thai people. Nonetheless, TNC are still at the bottom of the list of farmers' economic priorities (Choprakarn, 1988; Namdaeng, 1991; Laopaiboon and Jitpraneechai, 1999; Haitook et al., 2003; Klinhom et al., 2005; Simaraks *et al.*, 2007).

The loss of genetic resources is a major concern, and there is urgent need to find ways to save these resources from subsequent AI outbreaks. Many measures and ideas have been tried and proposed, with wide acceptance from other countries and World Organization for Animal Health (OIE) (Lekchareonsuk et al., 2006).

Most Thai farmers, generally, keep their TNC in the backyard. However, some farmers may take their birds to the fields when endemic diseases break out in the villages and/or during crop growing and harvesting seasons. Chickens are penned to protect them from predators or thieves at night. In most cases, there are no vaccination and de-worming for TNC; but some farmers may have local herbs for prevention and/or curing (Choprakarn *et al.*, 1983; Klinhom *et al.*, 2005 and Laopaiboon, 1990). This practice tends to satisfy the farmers involved.

TNC parent stocks are raised up to 2–3 years old depending on their performance. The next generation of chickens may descend from the same flock or be introduced from within or outside the village. Recommendations for parent-stock selection are, for males, high body weight and long legs, and for females, good maternal ability, i.e. producing at least 9 eggs/clutch, good behavior during incubation and taking good care of her broods. Another important criterion for parent stock is no cannibalism of their own chicks (Namdaeng, 1991; Laopaiboon and Jitpraneechai, 1999; Klinhom et al., 2005).

The survival rate of TNC, from one-day old to marketable size is 30-50 percent. Therefore, a typical hen can produce 10–15 market-sized birds annually (Choprakarn et al., 1983; Choprakarn et al., 1984 and Namdaeng, 1991). The general picture of the TNC production system is summarized in Figure 2.

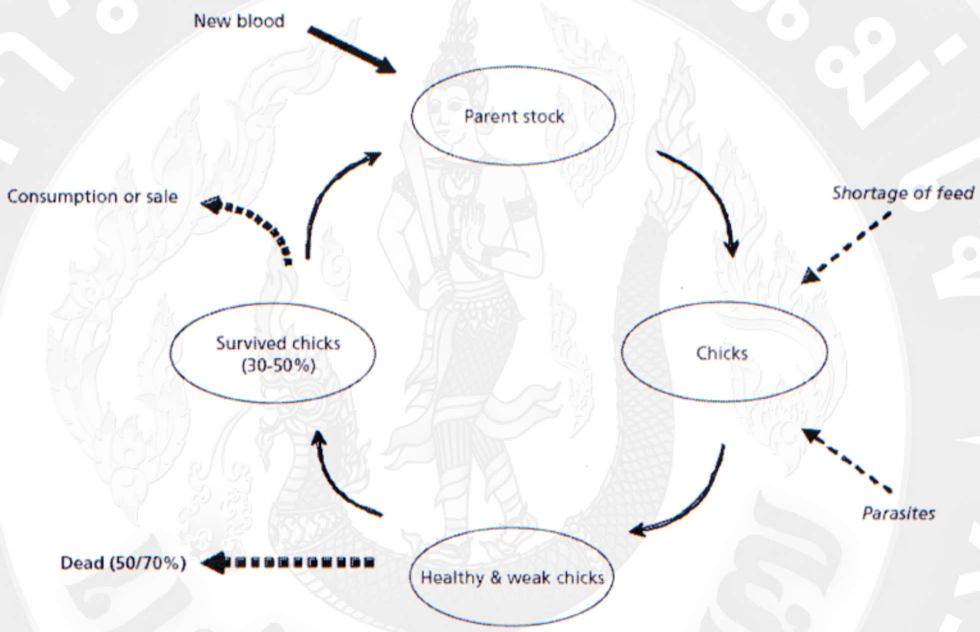


Figure 2 Raising native chickens by Thai farmer under traditional system

Source: Choprakarn et al. (1983)

Genetic resources of Thai native chicken

It is accepted by Thai researchers that Cochin Chinese and Burmese Red Jungle Fowl are the ancestors of TNC. The former is generally found in the east and the northeast of Thailand, while the latter are common in the east and the north (Royal Institute, 1995).

TNC is widely used as a parent stocks throughout the country that are primarily classified by appearances, especially their plumage. Male chickens are more colorful and also grow faster than females. Male plumage is mainly black, but the dorsal plumage on their necks, hackles, backs, saddles, and wings are in different colors such as yellow, green, dark brown, reddish brown, and/or white. Female feathers are basically black, dark brown, and/or brown; except for the Kai Chee (literally means "nun chicken") with all white feathers. Combs are usually pea, single, and/or rose. Shank colours are white, yellow, and/or black in both males and females. 17 groups of TNC have been categorized currently according to their feather colours (Reodecha and Choprakarn, 2005).

Both sexes of the TNC have almost same behavior as that of wild fowls with aggression a common character. This aggressive character in nature is to protect themselves or their broods from predators and enemies. Female has high maternal characteristics during nesting, egg laying and brooding. Although these behaviours are not desired for commercial-scale production, and are culled out, they must be conserved in the TNC kept under rural conditions (Choprakarn et al., 1998).

TNC productivity is very low compared to exotic breeds even under good management (high inputs). However, under rural area conditions (low inputs), TNC perform much better (Laopaiboon, 1990).

Maturity for female and male TNC is achieved at 6–8 and 8–12 months of age, and with 1.4–1.8 and 1.8–2.3 kg body weight, respectively (Choprakarn, 1988; Laopaiboon, 1990). Although, mating occurs at any time of the day, but is mostly occur during early morning and evening (Choprakarn et al., 1998; Klinhom et al., 2005).

A female TNC lays 3-4 clutches of eggs yearly and takes 2 weeks for laying, 3 weeks for hatching, and 6–10 weeks for taking care of her broods. Thus, a hen spends 10–15 weeks for each reproductive cycle (Choprakarn, 1988; Choprakarn et al., 1998; Katawatin et al., 1996). The time period of a hen's reproductive cycle depends on two main factors; feed and body weight. The hatching rate is 80–85 percent, higher in the cool season and lower in the hot and rainy season. Consequently, a typical hen produces 25–40 day-old chicks annually (Boonlear, 1989; Choprakarn, 1988; Klinhom et al., 2005).

Egg weight and body weight of day-old chicks are in the range of 45–55 and 33–35 grams, respectively with growth rate of 7–10 grams/day. The growth rate is highest between 12 and 14 weeks of age, and then it tends to decline. It takes about 4–5 months to reach marketable size with a 80–85 percent carcass (Choprakarn, 1988).

Local consumers consider TNC meat to be fine in texture and to have more flavour and less fat than the exotic breeds (Jaturasitha et al., 2002; Itarapichet et al., 2003; Wattanachant et al., 2004). This makes a choice of the consumers. TNC are more resistant to common diseases like Newcastle disease, fowl cholera and fowl pox than are exotic breeds and cross-breeds between TNC and exotics (Ratanasethakul and Laopaiboon, 1982; Ratanasethakul et al., 1983; Ratanasethakul *et al*., 1984; Ratanasethakul and Boonlear, 1989).

Feed and feeding systems of Thai native chicken

Two types of feeding for TNC are practiced aside from scavenging. In the first method, chickens are fed broken rice, rice bran, ground corn kernels, and/or cassava chips, depending on crops available, usually in the morning and evening. The amount of feed given is generally not enough for the birds' energy requirements, especially during the crop growing and harvesting seasons, as the farmers go to the fields early in the morning and return late in the evening. It is, therefore, suggested that, where there is plenty of natural feed, it might be better to feed TNC only once, in the evening. Doing this would force the chickens to scavenge extensively and save some inputs (Laopaiboon and Jitpraneechai, 1999; Klinhom et al., 2005).

Some farmers provide extra protein sources for their chickens by using termites and house-fly larva, but this is not convenient. A more practical method is by putting up light bulbs at night in the backyard to attract insects. This not only brings in a lot of insects as chicken feed, but for human food as well. Moreover, insect pests attracted to the light can be destroyed, saving crops from damages (Choprakarn et al., 1983; Klinhom et al., 2005).

The other feeding method is to use household waste products, together with natural feed available around the homestead. Most natural feeds are composed of high levels of protein, vitamins and minerals. The quantity and quality of these feeds depend on location and season. There are plenty in the rainy seasons but they are very scarce during dry seasons (Choprakarn et al., 1983; Laopaiboon and Jitpraneechai, 1999; Klinhom et al., 2005).

The most common natural feeds are earthworms, worms, termites, insects and plant leaves however cattle ticks and manure are also sources of high-quality protein for chickens. It was found that the more scavenging by the chickens, the fewer ticks and less dry manure left on the ground (Choprakarn et al., 1983; Laopaiboon and Jitpraneechai, 1999; Klinhom et al., 2005). Termites are rarely found on the ground around farmers' houses, this is because TNC are good predators of termites. Scavenging also affects the chickens' health and survival rates, as waste products are the main sources of the bacteria and parasites that affect the birds all year round.

Presently, the scavenging area for TNC is limited as available lands are used for development works like house construction and had adverse effects on the quantity and quality of natural feeds available to the chickens. Consequently, numbers of free-range TNC are expected to be lower in the future.

Marketing systems of Thai native chicken

TNC meat is one of a very few agricultural products that never face price problems. This is because of its high meat quality which results in high demand, while the supply is always low. In general, the price of TNC is about 1.5 times higher than that of broilers. However, most smallholders do not increase their production, as the practices do not fit well into their way of life and local conditions.

Marketing systems for TNC can be divided into three levels: person to person purchase in the villages; market or towns (wet or fresh market); and seasonal markets elsewhere (Choprakarn et al., 1998).

In person to person marketing system in the villages involves a direct contact between buyers and TNC farmers. Chickens are sold live and the bird size varies from young, 1 kg body weight, birds up to old parent stocks (Choprakarn, 1983; Klinhom et al., 2005). Although, this marketing system is occasional or seasonal yet it is significant.

In the case of fresh chicken meat markets in towns, the farmers carry their TNC to the markets very early in the morning to the town or market. The number of chickens brought by a farmer ranges from 3 to 10 with a desired weight is 1.0–1.5 kg/bird. If it is heavier than the desired weight, the price tends to go down due to the inferior, tougher, meat texture. In general, prices of female chickens are higher than those of males due to better texture and flavor of the meat. In this system, some farmers sell live birds directly to the consumers, while others sell slaughtered and dressed birds, with or without viscera.

Supply of TNC to these markets is not regular, and depends on the farmers' convenience. Most farmers often sell their birds when they need cash or get sick and/or the flock is too crowded. Otherwise, they were keeped their birds in the flock. Thus, TNC can be viewed as the farmers' "piggy bank" (Choprakarn, 1983; Choprakarn et al., 1998).

Seasonal markets happen at special occasions, such as a few days before Chinese New Year's Day. There is a very high demand of TNC throughout the country at this time of the year. A few weeks earlier, middlemen were collected mostly black-plumage female chickens of about 1 kg body weight. The chickens can then be sold for a price that is at least twice that obtained at normal times of the year. However, this seasonal market is facing uncertainty following the major Avain influenza outbreaks. The activity is limited by the government's Avain influenza prevention measures introduced in order to reduce the outbreak area (Choprakarn et al., 1998).

Health and disease control systems of Thai native chicken production

Some diseases like newcastle disease, fowl cholera and fowl pox account for 30-100 percent of the mortality rate of TNC annually. Newcastle disease is the most serious for all ages of chickens, occurs during seasonal changes from winter to summer and from summer to rainy seasons. Fowl cholera, the second most important disease, affecting mostly 3 month old chicks, occurs only in the summer season. Fowl pox can be found all year round in young birds. The other disease of young birds, infectious coryza, is also common in both rainy and winter seasons. Although fowl pox and infectious coryza do not cause immediate death, they weaken the chickens. This, subsequently, makes the chickens vulnerable to other diseases, and death often follows (Ratanasethakul and Laopaiboon, 1982; Ratanasethakul et al., 1983; Ratanasethakul et al., 1984; Ratanasethakul and Laopaiboon, 1986; Ratanasethakul and Boon-eg, 1989).

During out breaks, some farmers move their chickens to the crop fields far from the villages to reduce the chicken mortality rate to some extent. While in some areas, villagers are restricted from bringing commercial broiler meat to their home as it may carry diseases (Choprakarn *et al*., 1983; Namdaeng, 1991; Laopaiboon and Jitpraneechai, 1999; Klinhom et al., 2005).

External and internal parasites are common in TNC. Although they do not cause death directly, they affect the hatching and growth rates of the birds. When a hen gets external parasites, mostly in the summer, she were spend less time in the nest. The majority of external parasites are Menopon gallinae, Megninia spp. and Echidnophaga gallinacea which affect the hatching rate and young chicks (Ratanasethakul and Laopaiboon, 1986; Sangvarononda, 1993). Young chicks were weakened and vulnerable to other diseases and death often follows. In the case of internal parasites, chicks can easily be infected within a few weeks of scavenging on the ground, especially in the rainy season. These parasites include *Ascaridia galli, Raillietina echinobothridia*, and *Oxyspirura mansoni* (Ratanasethakul et al., 1984; Kunjara and Sangvaraononda, 1993; Kunjara and Sangvarononda, 1997; and Sukprasert et al., 2006).

Traditionally, vaccination is not practiced in the TNC production system, except in a limited number of villages where there is research work and/or extension programs implemented by various agencies (Kwaengsopha, 1989; Simarak et al., 2007). However, most farmers can identify the differences between Newcastle disease and fowl cholera, and also point to the time of outbreaks. Some farmers, especially those close to town, use human medical supplies for their chickens' health program. These include antibiotics to treat respiratory diseases and insecticides for external parasites. Herbs available locally such as *Andrographis paniculata, Curcuma longa, Stemona tuberose, Tinospora crispa, Cymbopogon citratus, Nicotiana tabacum, Ocimum tenuiflorum, Psidium guajava* and *Areca catechu* are very popular among farmers to keep their birds healthy. These herbs are used quite satisfactorily for disease prevention and/or internal/external parasite eradication (Klinhom et al., 2005; Sukprasert et al., 2006).

Thai government issued six major standard measures to control AI outbreaks which include surveillance, movement control, stamping-out and preemptive culling, and disinfection and carcass disposal. Ongoing measures to educate the farmers via public media, and by local staff at farm level, are very effective. The measures not only benefit AI control, but also enhance the control of other common diseases (Lekchareonsuk et al., 2006).

Cultural issues of Thai native chicken production

Thai people in rural areas are predominantly farmers or their occupations are related one way or another to agriculture. However, most young people from these areas prefer to seek work in towns or cities. Some of them may come back home as farm laborers during crop growing and harvesting times, but most of them need to visit home during important festivals like the traditional Thai New Year's Day in April. These seasonal economics and social activities result in an extra demand for food, and the most convenient source is TNC in the backyard. This encourages more than 90 percent of farmers to have TNC of their own (Choprakarn et al., 1983; Laopaiboon and Jitpraneechai, 1999; Haitook et al., 2003; Klinhom et al., 2005).

TNC like rice are part of the Thai farmers' way of life; both have been with the farmers for a very long time. The farmers' attitude towards their chickens is similar to that of people who keep dogs or cats. In terms of economics, TNC is much more beneficial. They are food for the farmers, a piggy bank at home, and can be used for cultural and religious activities (Klinhom et al., 2005).

Eggs, precursors of birth and symbols of life are an essential part or ingredient of many Thai offerings and sweets used in many rituals and ceremonies. Boiled eggs are an important part of decorative flower baskets used in many ceremonies, ranging from welcoming the birth of a child to weddings. In some instances, a boiled egg is shelled and then cut into halves; the outer egg white and then the inside texture is examined carefully. Then the future is told, to satisfy or warn those involved. In some places, people may make a wish together with putting an egg upright on its end; when this is done, a wish is likely to be accomplished. In some remote areas, a raw egg is used to indicate the burial site for the dead (Klinhom et al., 2005).

Cock-crow early in the morning is still used as alarm call for the villagers. In some areas, it is said that when chickens stretch out their wings to dry feathers, this is a sign that rain were soon fall. In a wedding ceremony in some villages, a cock and a pullet are presented together, representing a bridegroom and a bride, respectively. Most farmers are very proud to serve their own chickens to distinguished guests. For some traditional customs, a slaughtered, plucked and boiled whole chicken is often used as an offering for ancestor veneration and worship of village deities. In some instances, a cartilage under mandible is examined to indicate soil fertility and availability of natural food (Klinhom et al., 2005)

Cock fighting is still a popular pastime for many Thai men. This is an important cultural heritage from the Ayutthaya Era when king Naresuan's cock won a fight against the Burmese king's cock (Choprakarn, 1983). Cock fighting maintains a good source of TNC genetics through both natural and human selection. A lot of local wisdom involving TNC has been developed and passed down the generations as a result of this activity. Most herbs used for TNC originate from cock fighting.

Development of Thai native chicken

Research and development of TNC can be categorized into two levels: one for smallholders and another for commercial-scale production. In the past, smallholders were the main target for research and developmental work. The importance of TNC had been recognized and this issue was added to the Fifth National Development Plan of Thailand during 1982 to 1986. The main objectives were to increase protein sources through food and cash income for the farmers; and also to increase the number of day-old chicks per hen per year, and to decrease the mortality rate of the chickens (Choprakarn et al., 1998).

The number of hatchings can be increased up to two times by increasing the number of clutches from three to five or six per hen per year, while the number of hatchings in each clutch remains the same. The number of clutches can be increased by early separation of the hen from her broods. This stimulates the hen to enter the next reproductive cycle within one month of hatching, instead of the more usual two to three months. In this way, it takes only nine to ten weeks instead of 15 to 17 weeks for each reproductive cycle. In this case, day-old chicks are completely separated from the hen and are fed with concentrate for one month before they are let out to run with the flock. This is a critical period because chicks take at least two to three weeks to learn how to scavenge and survive. Weak chicks and high mortality are common during this growth stage (Boonlear, 1989; Choprakarn et al., 1998; Katawatin et al., 1996).

Crossing TNC with exotic breeds in order to increase the number of day-old chicks is not practical. About 30 percent of the hens do not brood and do not take care of their broods. Cross-breeds do not like to scavenge around and cannot cope as well as the TNC with the harsh environment in rural areas (Phalarask, 1985; Laopaiboon, 1990).

A good vaccination program (Newcastle disease, fowl cholera and fowl pox), associated with internal and external parasitic control, can satisfactorily lower the mortality rate of the flock from 50–70 percent to 30-40 percent (Ratanasethakul and Laopaiboon, 1982; Ratanasethakul et al., 1983; Ratanasethakul et al., 1984

Ratanasethakul and Laopaiboon, 1986; Ratanasethakul and Boon-eg. 1989; Sangvaranonda, 1993; Sukprasert et al., 2006). However, this is practiced sporadically due to intermittent vaccine supplies, and it does not fit well to the farmers' way of life.

Early chick separation and vaccination can increase the number of chickens at marketable size from 10–12 to 30–35 birds per hen per year. Even though there is extra cost for feed and vaccines, it is covered by the additional returns.

It is concluded that the traditional TNC production system with low inputs is still suitable for Thai farmers as supported by many researchers (Phalarask, 1985; Choprakarn et al., 1983; Choprakarn *et al*., 1998; Laopaiboon and Jitpraneechai, 1999; Klinhom et al., 2005). It is strongly recommended that there is no need to increase TNC production for smallholders by any other methods affecting their management systems.

A conservation program for TNC was formally started in 2001, based on collaboration between the Thailand Research Fund and the Department of Livestock Development. The main objective has been to prepare uniformity of TNC breeding stock for smallholders and for industrial-scale production. Four out of 17 groups, namely Pradu Hangdum (Black-tailed Pradu), Luang Hangkhao (White-tailed Yellow), Kai Dang (Red Chicken), and Kai Chee (Nun Chicken) have been selected according to their plumage colours. These distinct feather groups have now been established (Reodecha and Choprakarn, 2005) and are available to the farmers. Moreover, some of these four groups are being selected for pure male lines to be used in the commercial farms. However, local populations of TNC are still important as parent stocks for smallholders throughout the country.

Taxonomy of snails

Snails got its taxonomy in 1865, which falls under Phylum: Mollusca, Class: *Gastropoda*, Order: *Mesogastropoda*. The Mollusca is the second largest animal phylum, contributes with countless fossil and roughly 100,000 recent species, and many more remain to be discovered and investigated. In whichever tropical, temperate or polar ocean researchers have collected mollusks during the last 10 years. Depending on the region, 10-50% of species collected referred to new species. Regarding gastropod species, 80% or even more may be new when exploring abymssal depths of the oceans (Winston, 2012). Usually, species with individuals growing large, having massive shells and looking conspicuous are better represented in faunal lists than small and colorless, sluggish specimens living hidden between sand grains or parasitic in deep sea host animals. In these centuries, mollusk can taxonomy largely depended on shell morphology, and more recently also gross anatomy and radula features are compared and considered. Yet, the renaissance of (micro) morphology and especially the advent of molecular genetics greatly supplemented and enriched mollusk can taxonomy and diversity research. There is increasing evidence that cryptic species, i.e. those are not detectable by traditional methods, were boost the species richness in several sea slug groups. An exciting range of traditional and novel methods and tools are available to explore the hidden species diversity in mollusk, and also their morphological, functional and genetic diversity, i.e. any kinds of biological diversity. Ultimately, they are interested in how and why such an overwhelming organismic diversity evolved. Modern phylogenetic and evolutionary research provides exciting new insights into the secrets of mollusk life history.

Classification and ecology of snails

A snail is a mollusk, class gastro podia of any of a number of families. They have a soft body covered by a shell and are usually nocturnal. That's really all researcher can say on snails in general; 'snail' is not a very specific term. Annoyingly, this doesn't prevent farmers, even biologists, from using it as feed if it were a well-defined term. Snails live all over the world, from the arctic to tropics. They come in all sorts of varieties. Many are edible, some are poisonous. Some bite, some give birth to young ones. Amongst themselves, they contain all sorts of weirdness. They are often classified by the environment which they live, salt-water, fresh-water, or on land. This classification is based on convenience not on biological classification (Winston, 2012).

Land snails:

These snails have some specific adaptations so that they can live in the (comparatively) dry environment. They produce a layer of mucus to coat their body, helping keep the water in. This slime also helps them climb and hang on steep, even vertical, surfaces. Most land snails have lungs, but some manage with gills. Land snails have better eyesight in comparison to smell than water-dwelling snails; connected to this, terrestrial snails have eye stalks. The infamous French dish of escargot is a terrestrial snail of the family *Helix*. Giant African snails are often kept as pets (snails of the family *Achatina*). They can get over a foot long and weigh up to two pounds (Winston, 2012).

Fresh water snails:

It's interesting to note that many fresh water snails actually have lungs, and must come to the surface to breath (for example, members of the families *Lymnaeidae* and *Physidae*). Many fresh water snails are actually descended from snails that had adapted to life on the land, and then moved back to the water. Some of these have re-developed gills, while others have not. Humans have a great interest in fresh water snails, because various species can carry the schistosomiasis parasite, a major health concern in areas of the world where indoor plumbing has not yet become common. They use some species of fresh water snails for our aquariums (Apple snails, Trumpet snails and Ramshorn snails) (Winston, 2012).

Marine snails:

Salt-water snails are the largest group of snails, best known to human through the bright spiral shells that wash up on the shore. They are also harvested as food, particularly abalone and conch. You should not try to gather snails without reading up on the subject as some marine snails (family *Conidae*, genus *Conus*) secrete venom, which can be fatal to humans (Winston, 2012).

Pond snails

Taxonomy of pond snail

Pond snail (Figure 3.) which falls under Phylum: Mollusca, Class: Gastropoda, Order: Mesogastropoda, Suborder: Basommatophora, Superfamilies: Viviparacea, Family: Viviparidae, Genus: *Filopaludina (Siamopaludina)* and Species: *Filopaludina martensi*.

Filopaludina martensi live in canals and pond and feeds as a filter feeder. There are in development 0-14 juveniles in a brood-pouch of a female. Female give birth to juveniles mainly at night. Parasites of *Filopaludina martensi* include *Paragonimus siamensis* as the first intermediate host. The experience person can classify pond snail based on name, location, shape, etc.

Ecology of pond snail

Filopaludina martensi has been found to harbor several kinds of cercariae and metacercariae of *Echinostomatidae*. As this subspecies serves as local food to the people, it is an important intermediate host for Garrison's fluke infection (Echinostomiasis) and Angiostrongyliasis. A pond snail lives in fresh water and feed on seaweed, moss, etc. and reproduction takes every 15 days.

Figure 3 Pond snail (*Filopaludina martensi*)

A pond snail uses foot for movement and remains flat underneath the stone and decay wood stump and move slowly to seek the food. Pond snail usually don't like to be motionless however, when they do not have option, stays in the water often using fake foot at beside fan moustache back and forth. The enemy of a river snail are bird, duck, chicken and general poultry besides, still have aquatic large-sized animal, such as, snapping turtle gang and some fish.

Reproduction

Pond snails are hermaphrodites which mean that they are both male and female. All hermaphroditic snails can lay eggs. They can "mate" with themselves and thus only one can reproduce in an aquarium or pond. They also breed sexually as often as possible. Most snails lay eggs but some, like the trapdoor snail give live birth. Trapdoor snails and a few other species of snails (apple, golden inca, four horned, etc.) are not hermaphrodites and can only reproduce sexually.

Evaluation of the nutritive value of snails

David and Kompiang (1981) investigated Africa giant snail (*Acbatina fulica*) for chemical composition and nutritional value and the results are in the Table 1. The normal method of preparing the snail meal for these experiments was by boiling the freshly collected snail in water for 15 to 20 min. separated the shell from the flesh by hand, minced the flesh in a small power mincer, and dry the mince snail in a force-draught oven at 60 °C and sample of snail were analyzed for proximate constituents, calcium and phosphorus by AOAC (1975) method, and amino acid analysis was undertaken on one sample of meal form boiled snail. Amino acid concentration were determined on a Beckman amino acid analyzer (Model 119 CL)

El-Deek et al. (2002) reported that the giant snail meal snail bodies (meat) contain 60% CP on a dry matter basis (Gohl, 1975) and with the possible exception of methionine to be well balanced in amino acid content (Mead and Kemmerer, 1953). Creswell and Kompiang (1981) found that snail meal (*Achatina fulica*) contained 60% CP, 2% Ca, 0.8% P, 4.35% lysine, 1.0% methionine and 0.6% cystine on a dry matter basis and 14.2 MJ ME/kg dry matter.

Kaensombath (n.d.) reported that golden apple snails was components of shell and flesh as 319 and 360 g/kg (fresh basis), respectively. The chemical composition of fresh golden apple snails, includes dry matter, 181 g/kg, ash 149 g/kg DM and the crude protein (CP) 621 g/kg DM whereas that similar to fish meal, that in Laos contains 450-650 g CP /kg DM. The CP content of fresh golden apple snails (FGAS) in the Philippines (319 g/kg DM, with some shells) (FAO, 1997) is lower than the CP content of fish meal and FGAS in Laos. Growing pigs require essential amino acids for their muscle tissue development, especially lysine and methionine that are the most limiting amino acids in diets for growing pigs and that can be supplied by feedstuffs from animal tissue such as fish meal. However, in Laos, fish meal has to be imported from Thailand and was very expensive. Fresh golden apple snails was a good alternative protein resource in terms of both quantity and quality for fattening pigs, because of the high crude protein in the flesh of golden apple snails, and the good balance of amino acids for growing pigs, as shown in Table 2. The content of the two main limiting amino acids (lysine and methionine), for requirement of growing pigs are shown in table 2

Table 1 Chemical composition of snail meal (dry matter basis)

Item	Forms of snail		
	Snail meal[1]	Snail shell	Whole snail
Protein (N x 6.25), %	60.90	2.80	16.10
Ash, %	9.60	54.50	46.00
Crude fiber, %	4.50	-	-
Ether extract, %	6.10	1.00	2.00
Nitrogen-free extract, %	18.90	-	-
Gross energy, kcal/kg	5,110.00	-	-
Calcium, %	2.00	36.00	31.10
Phosphorus, %	0.84	0.14	0.32

Note: [1] Snail meal has amino acid (%Dry sample) : lysine (4.35%), histidine (1.43%), arginine (4.88%), threonine (2.76%), methionine (1.00%), leucine (4.62%), isoleucine (2.64), tyrosine (2.44%), phenylalanine (2.62%), valine (3.07%) and cystine (0.60%)

Source: adapted from David and Kompiang (1981)

Table 2 Amino acids content of fresh golden apple snail flesh (% DM)

Amino acid	Content
Histidine	5.08
Threonine	9.00
Arginine	13.82
Valine	9.23
Methionine	3.48
Phenylalanine	7.10
Isoleucine	8.19
Leucine	15.20
Lysine	4.18

Source: adapted from Kaensombath and Brian (n.d.)

Anthony et al. (1995) reported that the nutritive composition of fresh *limicolaria aurora as* presented in Table 3. The nutritive composition, mineral elements and amino acid compositions of fresh *limicolaria aurora* were determined. The moisture content of the sample was 71.24 g/ l00 g (wet weight). Crude protein, crude fat, and ash contents were 51.4, 9.70 and 11.76 g/l00g DM, respectively. Some anti-nutrients were also determined: total oxalate was 381 mg/l00 g DM while hydrocyanic and tannic acids were 112 and 592 mg/l00 g DM, respectively. Mineral analysis showed that *L. aurora* was rich in sodium, potassium, calcium, magnesium, phosphorus and zinc. Among the essential amino acids assayed, the sulphurcontaining amino acids with a chemical score of 46.0% appeared to be the most limiting when compared with the essential amino acid pattern of whole hen's egg.

Table 3 Nutrients composition of *limicolaria aurora* snail.

Nutrients	Contents [1/]
Proximate composition (g/100 g DM)	
Moisture (wet weight)	71.24 ± 1.55
Ash	11.76 ± 0.55
Crude protein	51.4 ± 0.35
Crude fat	9.70 ± 0.47
Carbohydrate	27.1 ± 1.81
Caloric value (kcal/100 g)	349 ± 1.43
Mineral element (mg/100 g DM)	
Na	178 ± 1.41
K	533 + 0.05
Mg	771 ± 0.01
Ca	401 ± 0.08
P	636 ± 0.02
Zn	259± 1.79

Note: [1/] Amino acids of *Limicolaria aurora* such as (g/16 g N): Isoleucine, Leucine, Lysine, Methionine, Cystine, Tyrosine, Threonine, Tryptophan, Valine, Methionine + Cystine, Phenylalanine+Threonine, Arginine, Histidine, Alanine, Aspartic acid, Glutamic acid, Glycine, Proline and Serine contents were 7.3, 11.5, 7.2, 1.4, 0.9, 6.7, 5.9, 3.9, 7.9, 2.3, 12.6, 0.3, 3.7, 6.9, 7.8, 13.5, 6.5, 5.6 and 4.0 g/16 g N, respectively.

Source: adapted from Anthony et al. (1995)

Fermented or silage feed

The principle of fermented silage is similar to that of acid silage resulting acidity arising from the growth of lactic acid producing bacteria. Plants or animals, preferably chopped or minced, are placed in non-metallic vats and mixed with a single carbohydrate source, such as cassava, sweet potato or molasses or a mixture of these, and stored airtight. In order for fermentation to start almost immediately, the addition of 20 to 30 percent of molasses has been recommended (FAO, 2012). Periodic agitation and temperatures of at least 20°C tend to induce rapid liquefaction of the raw material (Green et al., 1983).

Fish wastes could be preserved directly in cane molasses was first proposed (Pérez, 1988) during an FAO Expert Consultation in 1986 to promote sugar cane as animal feed. At that time, it was suggested that the silage could be used as a source of protein for geese. Trials have shown that, in order to expedite the ensiling process, the raw material should preferably be chopped or ground prior to mixing with an equal amount (weight) of molasses (4.5 litres of final molasses weighs 5.5 kg). Although the osmotic pressure of the molasses causes an initial dehydration of the raw tissue, an acidic fermentation also occurred, which tends to preserve this material (FAO, 2012).

In Morocco, a mixture (50:50 w/w) of molasses and drained ground fish wastes, left uncovered and stirred daily, required a period of ten days to produce a stable final product with a pH of 4.5. The fish silage was then formed into blocks in order to have solid feeding material for sheep, goats, horses and camels. The procedure involved adding a 1% supplement of minerals and vitamins and about 20% ground straw. The blocks of approximately 7 to 8 kg were dried in the sun for two to four days. One further recommendation was to use about 5 percent cement during preparation of the blocks (FAO, 2012).

The experiences in the preparation and use of biological fish silage in Latin America were summarized in the proceedings of the FAO Second Expert Consultation on Technology of Fish Products (FAO, 1989). Various kinds of fish residues and by-catch have been preserved as silage using several sources of carbohydrates for fermentation by natural occurrence or inoculated microorganisms. The results of the inclusion of fish silage in the diets of pigs, chickens and beef cattle have demonstrated that it is a valuable source of protein that can in most cases, replace fishmeal or other traditional protein sources.

Domínguez (1988) suggested that if the objective was to prepare a complete fish silage ration, using roots as the principal source of carbohydrates, then the following general formula might be used (percentage air-dry): roots, 30 to 50 percent; molasses, 10 percent; and fish wastes, 40 to 60 percent. In Viet Nam, fish silage made from shrimp heads, fresh blood (abattoir) and molasses in proportions of 5:3:2, respectively, and fermented for a period of ten days reportedly had a pH of between 4.3 and 4.5 as well as a "pinkish colour, nice flavour and soft texture" (AHRI, 1993).

Snail silage

From the proximate analysis, the minced golden apple snail mainly consists of 57.28% protein (Srinivet, nd.). It could be suitably used as a protein substitute for aquaculture feed production. However, golden apple snail easily spoils thereby proving to be an excellent source of nutrients for microbial growth. An alternative use of golden apple snail in order to improve their quality for a feed ingredient is the fermentation by lactic acid bacteria. The golden apple snail silage is the product of a controlled fermentation process in which carbohydrates added to minced snail are fermented with lactic acid bacteria. Bello *et al.* (1993) also reported similar fish silage production. Furthermore, the ensiled process is rapid and efficient in tropical countries because the technology is simple. Moreover, the equipment is cheap and the production scale may be varied at will.

The objective of this work was to investigate the production of the golden apple snail silage and the effect of molasses, a carbon source for lactic acid bacteria, on golden apple snail silage production. The experiment conducted by Kittipong *et al.* (2006) on Golden apple snails (*Pomacea caniculata*), obtained from rice field in Thasala district, Nakorn Si Thammarat, Thailand, and was dipped into boiling water for 2 minutes. The meat was removed from shell and then minced using a Hobart mincer. The minced meat was blanched for 5 minutes and stored at –20 °C. Minced golden apple snail was thoroughly mixed with molasses and 10% of the prepared inoculum. The molasses concentration varied in terms of the golden apple snail to molasses ratio of 1: 0.05, 1: 0.15, and 1: 0.25 (kg: litre). The mixture was incubated at ambient temperature for 15 days. During incubation, the silages were stirred daily by swirling and 50 g of sample was taken for analysis on days 0, 3, 5, 10 and 15. Sample was incubated in boiling water for 30 minutes before analysis. It was found that the fermentation of golden apple snail with lactic acid bacteria L1/2, with the addition molasses of 0.15 litres per kg of minced golden apple snail was successful in stabilizing and preventing it from spoilage. During the course of fermentation, the liquid level increased and the color became more brownish. The pH value sharply dropped from 8.18 to 5.07 within the first 3 days of fermentation and varied with a narrow range of 4.0-5.0, corresponding to the preparation of lactic acid fermented shrimp (Fegbenro and Bello-Olusoji, 1997). The stability of pH at the end of fermentation could be the effect of amino acid buffering action and other salts in the silage (Fegbenro, 1996). In addition, changes in TTA corresponded to the changes in pH as shown in Figure 4. However, the TTA was not related to pH that suddenly decreased at day 3 because of the buffering capacity of the silage. The highest TTA was achieved with a value of 1.72 % at the end of incubation. Acidification of silage was an important factor in the inhibition of spoilage microorganisms as lactic acid bacteria are known to synthesize anti-microbial compounds such as bacteriocin, acetoin, and hydrogen peroxide (Lindgren and Dobrogosz, 1990). These affected the growth of spoilage microorganisms. In addition, free amino acids increased steadily with the maximum value of 1.27 mg/g sample and then decreased to 0.75 mg/g sample after 10 days. This could be explained that the production of lactic acid in the silage enhanced protein hydrolysis, resulting in an increasing of free amino acid contents. Nevertheless, a decrease of free amino acids at the end of fermentation, occurred from the growth of undesirable organisms in silage, could be reflected by a continual decrease of pH. Further, the interactions between free amino acids and sugars in the unutilized molasses also caused the reduction of free amino acids. Some amino acids, such as tryptophan are labile under acid conditions and also affected by the temperature and the duration of acid treatment (Fegbenro and Bello-Olusoji, 1997). From the result, the fermentation time in the further study would be terminated at 10 days because the highest free amino acid content in the golden apple snail silage was attained.

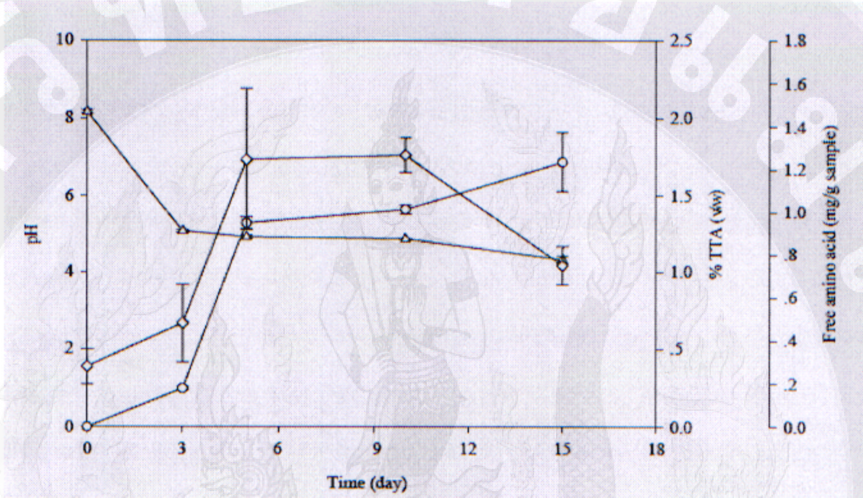


Figure 4 pH (-Δ-), total tritratable acidity (-□-) and free amino acid production (-O-) during the fermentation of golden apple snail silage.

Source: Kittipong et al. (2006)

Effects of molasses on golden apple snail silage production

Generally, agricultural waste, such as shrimp waste, fish waste or even golden apple snail, has a low concentration of fermentable sugars. A carbon source like glucose, lactose, cassava or molasses must be added for bacterial growth (Fegbenro and Bello-Olusoji, 1997; Shirai et al., 2001). The effects of molasses concentration on apple snail fermentation was investigated by varying the amount of golden apple snail and molasses at the ratio of 1: 0.05, 1: 0.15, and 1: 0.25 (kg : litre). From Figure 5a, the pH value suddenly dropped to 4.0 - 5.0 after 3 days of fermentation. For the behavior of silage with the added molasses, it was similar to that with added sucrose and lactose, which was reported by Cira et al. (2002) on lactic acid fermentation of shrimp wastes for chitin recovery. However, the silage behavior was also depended on the characteristic of lactic acid bacteria (Cira et al., 2002). The total tritratable acidity (TTA) as a function of molasses concentration during the fermentation was shown in Figure 5b. It was found that the TTA suddenly increased at the first 3 days and slightly increased until the end of fermentation. Nonetheless, at a ratio of 1: 0.05, the TTA steadily increased and then became constant whereas TTA at a high golden apple snail to molasses ratio continuously increased. The result indicated that the growth of lactic acid bacteria had reached the stationary phase and allowed undesirable organisms to grow. A gradual increase of free amino acid content was consistent to the TTA change in silage. From Figure 5c, free amino acid concentration increased with a decrease of golden apple snail to molasses ratio. At the high ratio of golden apple snail to molasses, the catabolic repression of sucrase production may be induced; therefore, the growth of lactic acid bacteria was inhibited. Surcease is a key enzyme in sucrose metabolic pathway of sucrose-consuming lactic acid bacteria (Steinmeitz, 1993 cited by Kittipong et al. 2006). Moreover, lactic acid bacteria were also inhibited by a high osmotic pressure. At low ratio of golden apple snail to molasses, both the highest free amino acid and TVB-N were attained at the end of fermentation. Figure 3 shows that at each ratio, the TVB-N at the end increased with a decrease of golden apple snail to molasses ratio. Total volatile base nitrogen (TVB-N) is an indicator of protein spoilage in the fermentation process. These total volatile base nitrogen compounds are amine and ammonia, which are the products of protein decomposition in the fermentation process. In addition, the TVB-N of more than 25 mg/ 100 g sample is not acceptable in feed (Suttawat, 2005). The results revealed that the optimal molasses content in golden apple snail silage production is the ratio of 1 kg of minced golden apple snail to 0.15 litres of molasses and free amino acid concentration was attained at 1.47 mg/g sample.

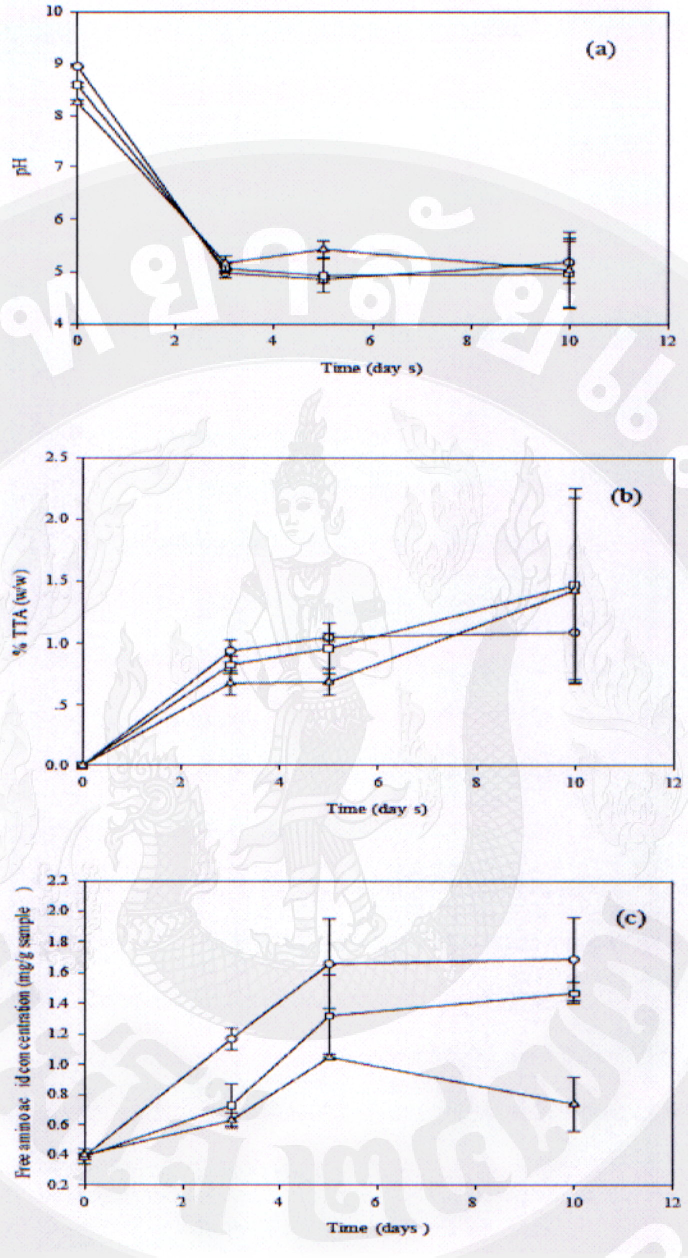


Figure 5 pH (a), TTA (b) and free amino acid concentration (c) during the fermentation of golden apple snail silage at various ratios of golden apple snail (kg) to molasses (litre).:

-○ - 1:0.05, -□ - 1:0.15, - Δ- 1:0.25

Source: Kittipong et al. (2006)

Effect of snail meal for chicken production

David and Kompiang (1981) conducted experiment on the effects of snail meal in chicken. Five experiments were carried out using day old, sexed broiler chickens of the same commercial strain. Mash diets were fed to groups of 40 chickens divided into four replicate pens each of 10 birds (2 pens male and 2 pens female). Birds were housed in wire-floored brooder cages. In the 1st experiment, birds were fed levels (0, 5, 10, 15 and 20%) of snail meal prepared from either raw or boiled snails. The 2nd experiment was to compare the feeding value of snail meal which had been subjected to various heat treatments. Snail meal was included in all diets at 20%. Treatments were A) raw (unboiled), B) washed for 2 min in boiling water, C) boiled for 5 min, D) boiled for 10 min, E) boiled for 15 mins, and F) boiled for 20 mins. In the 3rd experimental, treatments consisted of graded levels of snail meal prepared from boiled snails. Levels were 0, 5, 10, 15, 20, 25 and 28.6% of the diets. An eighth treatment contained 20% snail meal with 0.25% DL-methionine. Other diets contained 0.1% DL-methionine. The 4th experiment was designed to investigate further the response to methionine observed in the 3rd experiment. DL-methionine was added to the control and to 20% snail meal diets at levels up to 0.3%. The effect of substitution fish meal with snail meal was studied in the 5th experiment. Levels of snail meal were 5, 10 and 20% and fish meal 5 and 10%. One diet contained neither snail meal nor fish meal. It was found that diet contained with boiled snails up to 20% of the diet or meal prepared from raw snails up to 10% of the diet resulted in weight gains and feed conversion rations, which were better than the control diet (Table 4). However, weight gains were considerably reduced when 15 or 20% raw snail meal ware fed. Poor performance of chicken fed 20% raw snail meal was again observed in the 2nd experiment (Table 5). Washing the raw snail meal in boiled water for 2 minutes significantly improved performance but 15 or 20 minutes boiling was necessary to maximize weight gains.

When graded levels of boiled snail meal were fed in the 3[th] experiment, up to 10% snail meal gave weight gains and feed conversion ratios that were not different from the control group (Table 6). Levels above 15% snail meal produced depressions in weight gain but not in feed conversion ratio. A high level of supplementary DL-methionine (0.3%) corrected the growth depression associated with a diet containing 20% snail meal. This response to methionine was confirmed in the 4[th] experiment (Table 7).

Improved performance was obtained from chickens when including 5 or 10% of either snail meal or fish meal in a corn-soyabean meal diet (Table 8)

Table 4 Performance of chickens fed grade levels of snail meal from boiled or raw snail [1]

Treatment	Weight gain (g)	Feed : gain	Mortality (%)
Non snail meal	676^{b}	1.75^{ab}	5.0
5% Boiled snail meal	722^{a}	1.73^{ab}	2.5
10% Boiled snail meal	742^{a}	1.63^{a}	2.5
15% Boiled snail meal	713^{a}	1.64^{a}	0
20% Boiled snail meal	680^{b}	1.63^{a}	0
5% Raw snail meal	718^{a}	1.73^{ab}	0
10% Raw snail meal	720^{a}	1.67^{ab}	5.0
15% Raw snail meal	517^{c}	1.76^{b}	2.5
20% Raw snail meal	332^{d}	2.09^{c}	2.5

Note [a, b, c, d] Values in the same column with a common superscript letter are not different ($P>0.05$).

[1] Chickens fed 1 to 28 days of age.

Source: adapted from David and Kompiang (1981).

Table 5 Performance of chickens fed snail meal from snails subjected to different processing methods [1,2]

Treatment	Weight gain (g)	Feed : gain	Mortality (%)
Unboiled (raw)	254[d]	2.01[c]	0
Washed 2 min.	310[c]	1.95[b]	0
Boiled 5 min.	439[b]	1.57[a]	5.0
Boiled 10 min.	409[b]	1.56[a]	7.5
Boiled 15 min.	482[a]	1.51[a]	2.5
Boiled 20 min.	480[a]	1.52[a]	0

Note [a, b, c, d] Values in the same column with a common superscript letter are not different (P>0.05).

[1] All diets contained 20% snail meal.

[2] Chickens fed 1 to 21 days of age.

Source: adapted from David and Kompiang (1981).

Table 6 Performance of chickens fed graded levels of snail meal[1,2]

Snail meal (%)	Weight gain (g)	Feed : gain	Mortality (%)
0	784[a]	1.68[c]	0
5	791[a]	1.67[bc]	2.5
10	785[a]	1.63[abc]	0
15	788[a]	1.60[ab]	5.0
20	732[b]	1.61[ab]	2.5
25	735[b]	1.57[a]	0
28.6	690[c]	1.62[abc]	0
20	778[a]	1.58[a]	2.5

Note [a, b, c] Values in the same column with a common superscript letter are not different (P>0.05).

[1] Chickens fed 1 to 28 days of age.

[2] The last treatment contained 0.25% supplemental DL-methionine. All other treatments contained 0.1% supplemental DL-methionine.

Source: adapted from David and Kompiang (1981).

Table 7 Performance of chickens[1] fed control and snail meal diets containing various levels of DL-methionine supplementation

Treatment	Weight gain (g)	Feed : gain	Mortality (%)
0% Snail meal + 0.1 methionine	511^{a}	1.47^{ab}	0
0% Snail meal + 0.3 methionine	501^{a}	1.48^{ab}	0
20% Snail meal	463^{b}	1.59^{b}	0
20% Snail meal + 0.1 methionine	493^{a}	1.56^{b}	0
20% Snail meal + 0.2 methionine	492^{a}	1.46^{ab}	2.5
20% Snail meal + 0.3 methionine	508^{a}	1.45^{a}	2.5

Note [a, b] Values in the same column with a common superscript letter are not different (P>0.05).

[1] Chickens fed 1 to 21 days of age.

Source: adapted from David and Kompiang (1981).

Table 8 Performance of chickens fed diets containing various levels of snail meal or fish meal [1]

Treatment	Weight gain (g)	Feed : gain	Mortality (%)
Control	476^{b}	1.58^{c}	0
5% Snail meal	511^{a}	1.53^{bc}	0
10% Snail meal	504^{a}	1.51^{ab}	0
5% Snail meal	500^{a}	1.53^{bc}	0
10% Snail meal	510^{a}	1.49^{ab}	2.5
5% Fish meal	518^{a}	1.51^{ab}	0
10% Fish meal	518^{a}	1.51^{ab}	2.5
20% Fish meal	516^{a}	1.46^{a}	0

Note [a, b, c] Values in the same column with a common superscript letter are not different (P>0.05).

[1] Chickens fed 1 to 21 days of age.

Source: adapted from David and Kompiang (1981).

El-Deek et al. (2002) studied the impact of feeding dried giant snail meal (*Theba pisana*) as an additive and feed component in different concentrations in broiler diets on performance, proportion of edible organs, mineral content and special characteristics of tibia, and some blood parameters.

The whole dried giant snail meal (DGSM) was evaluated in broiler diets in terms of chemical composition and as a feedstuff for broiler diets. It was used in trial 1 as a feed additive at 0, 0.05, 0.10, 0.15 and 0.20%. In trial 2, DGSM was included in the growing and finishing diets for broilers at 0, 2.0, 4.0 and 6.0%. Moreover, DGSM was used in trial 3 as a calcium and phosphorus supplement at 1.5% of the diet to replace 24.5 and 33.3% of bone meal in the growing and finishing diets, respectively. In trial 4 the broiler grower diets was replaced by the same percentage of the DGSM at 0, 2.0, 4.0 and 6.0%. The chemical composition of the DGSM revealed 95.8% DM, 15.2% CP, 1.68% EE, 2.25% CF, 47.8% ash and 8.91% NFE. The energy value was calculated as 4.80 MJ AMEn/kg (based on chemical composition). The mineral contents of DGSM was 24.2% Ca, 0.94% P, 0.47% Na, 0.31% K and 16.2% Mg. Performance of broilers in trial 1 was not affected significantly by DGSM when fed either at 0.05, 0.10, 0.15, or 0.20% as a feed additive. In trial 2, increasing DGSM more than 2% of the diet decreased productive performance and dressing percentage. Performance of broilers in trial 3 fed DGSM at 1.5% in the diet as Ca and P supplements was lower than the control diet. Results of trial 4 indicated that DGSM up to 6% in grower diets had no negative effects on weight gains, FCR and the utilization of protein and energy when fed for a shorter period during 7–28 d of age. Tibia ash, breaking strength and mineral contents were not affected by different levels of DGSM supplements in trials 2 and 3. Chemical compositions of breast meat were not affected significantly by including different levels of DGSM as well as levels of plasma protein, glucose and plasma Ca, P, Na and K. It was concluded that DGSM could be used in broiler diets up to 6% without adverse effects on performance, total edible parts and internal organs.

Table 9 Effects of different levels of dried giant snail meal (DGSM) supplemented to broiler diets as a feed additives on performance, carcass characteristics and internal organs of broiler chicken (Trial 1)

Parameter	Level of DGSM in diet (%)					SEM
	0.0	0.05	0.10	0.15	0.20	
Performance of broiler chicks during 4–42 d of age						
Initial body weight, 4 day	79.0	81.8	79.6	78.2	78.0	2.89
Body weight, g at 6 wk of age	1,279	1,279	1,339	1,338	1,367	78.3
Weight gains, g	1,200	1,197	1,259	1,260	1,289	77.5
Feed intake, g	2,798	2,863	2,848	2,867	2,844	113
FCR, g/g	2.33	2.39	2.26	2.28	2.21	0.123
Carcass characteristics and internal organs						
Total edible parts, % BW	73.3	74.4	75.3	74.7	74.8	1.30
Liver, % BW	2.79	3.02	2.98	3.44	2.99	0.37
Gizzard, % BW	2.16	2.07	2.14	2.11	2.00	0.117
Pancreas, % BW	0.24^{b}	0.29^{a}	0.26^{ab}	0.28^{ab}	0.24^{b}	0.012
Spleen, % BW	0.21	0.16	0.19	0.19	0.28	0.014

Note $^{a, b}$ Means within the same row not sharing a common superscripts differ significantly (P<0.05)

Source: adapted from El-Deek et al. (2002)

Table 10 Effects of different dietary levels of dried giant snail meal (DGSM) on performance, carcass characteristics and body organs of broiler chicken (Trial 2)

Parameter	Level of DGSM in diet (%)				SEM
	0	2.0	4.0	6.0	
Performance of broiler chicks					
Initial body weight g, 1 day of age	48.0	49.0	48.0	48.0	1.23
Body weight, 8 wk of age (g)	1,833[a]	1,798[a]	1,520[b]	1,474[b]	104
Weight gains, 1–56 d of age (g)	1,785[a]	1,749[a]	1,472[b]	1,426[b]	103
Feed intake, 1–56 d of age (g)	4,107	4,285	3,942	3,855	112
FCR g/g , 1–56 d of age	2.30	2.45	2.68	2.70	0.179
Carcass characteristics and internal organs, (% BW)					
Total edible parts[1/]	71.5	70.2	68.4	69.4	1.25
Breast	19.0	17.6	19.3	17.5	1.24
Thigh	21.5	21.1	20.1	21.0	0.49
Liver	2.31	2.25	2.46	2.76	0.28
Gizzard	2.22	2.37	2.03	2.00	0.12
Pancreas	0.25[ab]	0.26[a]	0.26[a]	0.24[b]	0.036
Spleen	0.18	0.21	0.25	0.19	0.059

Note [a, b] Means within the same row not sharing a common superscripts differ significantly (*P*<0.05)

Source: adapted from El-Deek et al. (2002)

Table 11 Effects of different dietary levels of dried giant snail meal (DGSM) on plasma constituents, tibia mineral and plasma mineral constituents of broiler chicken (Trial 2)

Parameter	Level of DGSM in diet (%)				SEM
	0	2.0	4.0	6.0	
Plasma constituents at 56 d of age					
Plasma glucose (mg%),	153	143	139	126	9.94
Plasma protein (g/100 ml)	4.12	3.42	4.14	3.80	0.49
Tibia ash, Ca and P, %					
ash	36.3	39.0	38.1	35.1	1.99
Ca.	12.5	14.8	14.0	11.6	1.01
P.	6.40	6.51	6.24	5.73	0.27
Plasma mineral constituents					
Ca, mg/100 ml	9.84	9.76	6.11	5.80	0.77
P, mg/100 ml	3.68	3.53	2.90	2.60	0.41
Na, meq/L	118	115	112	110	4.36
K, meq/L, %	10.5	7.17	5.43	5.43	0.77
Mg. Mg/100 ml	3.80	3.70	3.12	3.07	0.48

Note [a, b] Means within the same row not sharing a common superscripts differ significantly (*P*<0.05)

Source: adapted from El-Deek *et al.* (2002)

Reglain et al. (2012) determined that Giant African Snail (GAS) could be used as a component of broiler feed to aid the poultry industry and contribute to an effective pest management system. The meals were analyzed for crude protein, fat and ash (Table 12) and feed treatments contained snail meal at 0 (control), 5, and 10%. A total of 30 broiler chickens (27 days of age) were divided into three groups (10 birds/treatment). The experiment lasted 3 weeks. The birds were supplied food *ad libitum* and their food supply replenished twice daily with specific amounts of feed. Each bird’s consumption rate, growth rate, and feed-to-weight conversion ratios

(FCR) were calculated and their carcass weights were determined after slaughter at 47 days of age (1 week past the industry norm).

The local commercial target weight of 2.11 kg after 40 days of age was attained for all treatments and there were no differences in weights for each treatment throughout the experiment (Figure 6). The cumulative FCR over the entire 3 week feeding trial was the same for all treatments (Figure 7). It was found that GAS with shell has more ash compare to GAS without shell, however, crude protein and fat was more in GAS without shell (Table 12)

Table 12 Nutritional analysis of GAS with and without shell

	Ash (%)	Fat (%)	Crude protein (%)
GAS with shell	72	0.7	19.32
GAS without shell	10	2.3	71.61

Source: adapted from Reglain et al. (2012)

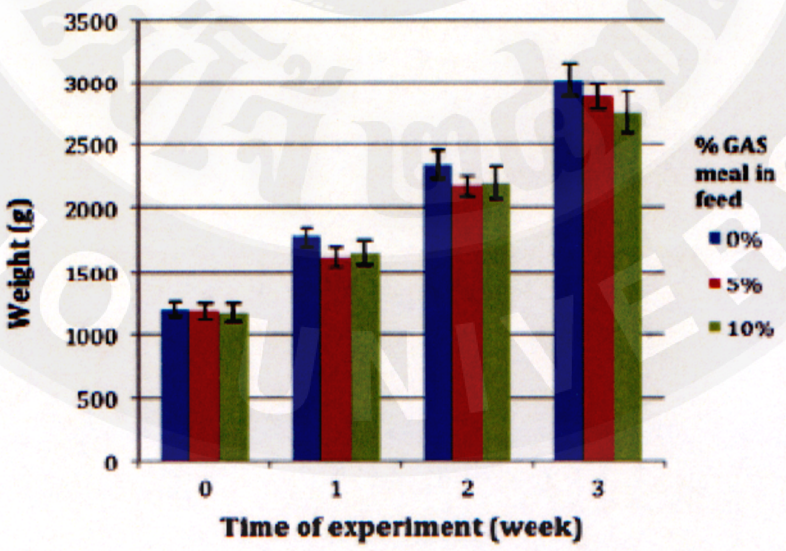
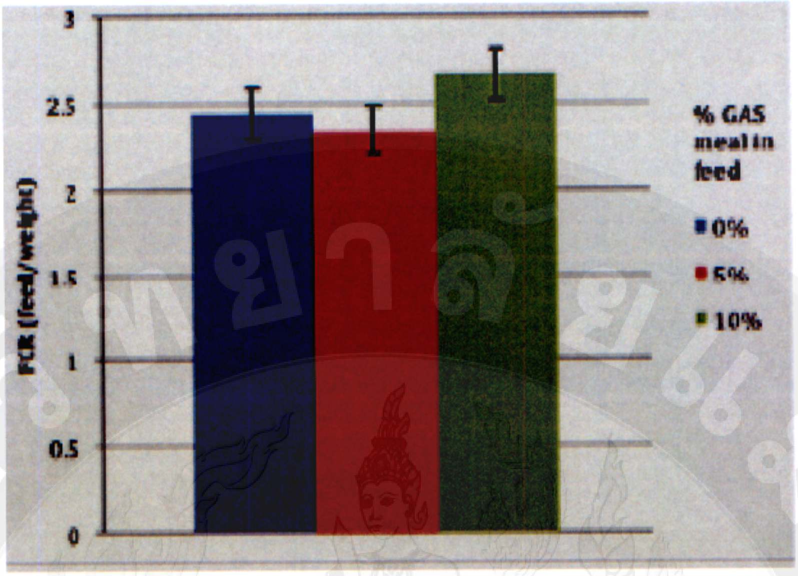


Figure 6 Average weight per treatment

Source: adapted from Reglain et al. (2012)



GAS (%)

Figure 7 Cumulative FCR mean/trial.

Source: adapted from Reglain et al. (2012)

The study conducted by Diomande et al. (2012) was based upon 330 chicks of a day old which were fed on diets containing 1 to 10 % of snail meal (*Achatina fulica)* in substitution of fish meal. Snail meal was assessed for its nutritive value in broilers diets. At the starting period, the diet with 3, 4 and 5% of snail meal showed some signs of consumption which were higher (1.4 and 1.6%) whereas the others had lower signs of consumption (1.2 to 1.4%) during the first week. But from the 2nd week, the signs of consumption were appreciably identical and constant (Table 13). Growth rates in the starter phase showed a negative curvilinear response to increasing proportions of snail meal (Figure 8; R^2 = 0.90). Growth rates were maintained as snail meal replaced up to 30% of the fish meal followed by a steady decline up to 100% replacement of the fish meal. In the grower stage (Table 13) there was also an indication of a curvilinear response with a slight decrease as the snail meal was raised from 0 to 30% replacement of fish meal followed by an increase as snail meal replacement increased from 30 to 100% of fish meal (Figure 9; R^2 = 0.44).

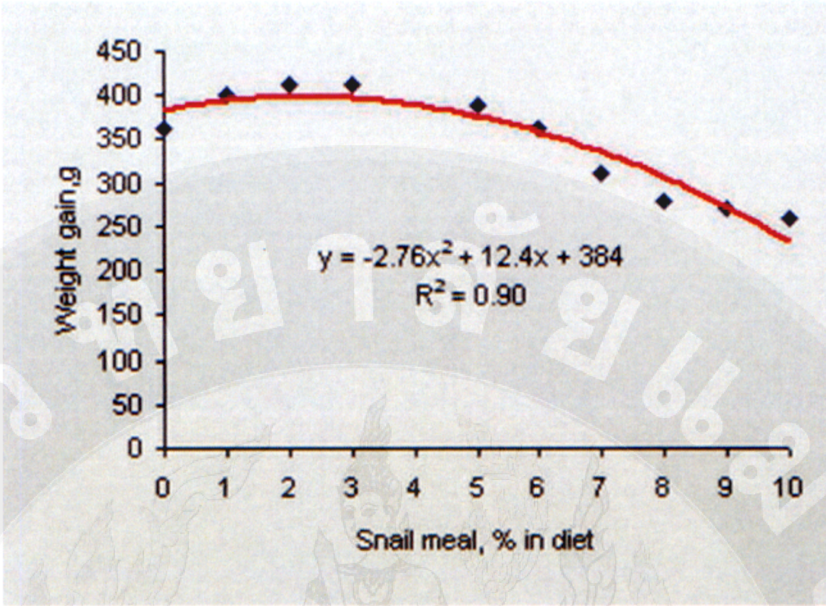


Figure 8 Effect of level of snail meal in the diet on growth rate during the starter phase.

Source: adapted from Diomande et al. (2012)

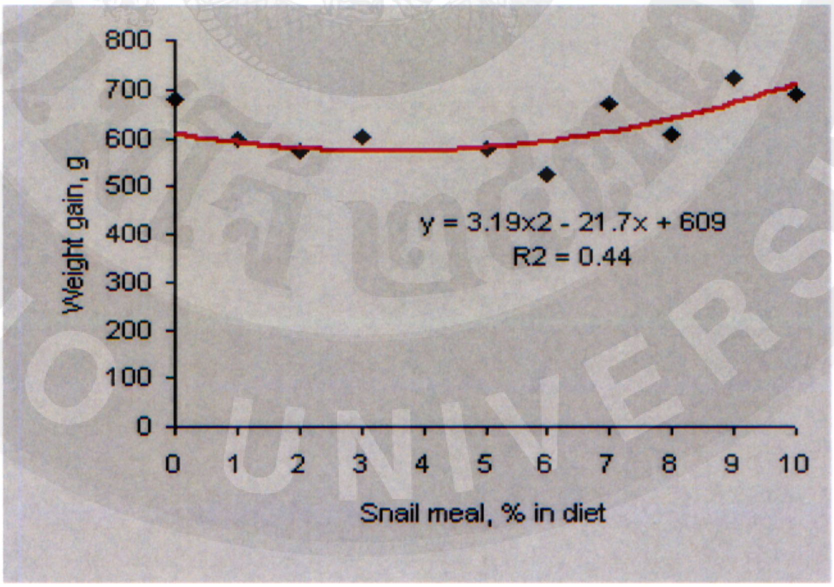


Figure 9 Effect of level of snail meal in the diet on growth rate during the growth phase.

Source: adapted from Diomande et al. (2012)

Table 13 Feed cost and growth performance of broiler chicken fed increasing levels of snail meal replacing fish meal (0-28 days)

	Snail meal in diet, %										
	0	1	2	3	4	5	6	7	8	9	10
Feed cost (FCFA/kg)	353	351	349	347	345	342	340	338	336	333	331
Live Wight, g											
Initial	34.7	35.3	36.7	40.3	42.1	42.8	32.9	32.1	33.1	33.9	32.1
Final	397	436	449	452	359	430	397	344	311	303	290
Increase	362	400	412	411	317	388	364	312	277	269	258
Feed intake, g	866	993	1,096	1,111	888	1,159	1,111	967	804	822	794
Feed DM conversion	2.39	2.48	2.66	2.70	2.80	2.99	3.05	3.10	2.90	3.06	3.08

Source: adapted from Diomande et al. (2012)

Table 14 Feed cost and growth performance of broiler chicken fed increasing levels of snail meal replacing fish meal (29-42 days)

	Snail meal in diet, %										
	0	1	2	3	4	5	6	7	8	9	10
Feed cost (FCFA/kg)	354	352	350	348	345	343	341	339	337	334	332
Live weight, g											
Initial	397	436	449	452	359	430	397	344	311	303	290
Final	1,075	1,031	1,022	1,056	892	1,011	920	1,015	918	1,026	978
Increase	678	596	574	605	533	580	523	671	606	724	688
Feed intake, g	1,891	1,596	1,554	1,723	1,493	1,381	1,234	1,597	1,426	1,729	1,774
Feed DM conversion	2.79	2.68	2.71	2.85	2.80	.38	2.36	2.38	2.35	2.39	2.58

Source: adapted from Diomande et al. (2012)

CHAPTER 3

MATERIALS AND METHODS

Experiment 1 The study on population density of pond snail (*Filopaludina martensi*) in fish (Nile Tilapia) pond.

The survey on the pond snail in fish pond of Nile Tilapia farmer's group in Phan district, Chiang Rai province was carried out using random sampling. The study period was 2 months (one month each) collected data for the density of population as furnished below. Each pond was randomly surveyed on pond snail population. By using sieve with a diameter at 40 cm and a frequency at 1 cm^2 fishing net, pressing against on the ground under the water pressure from the tank to 1 meter towards the edge of a pond area of about 32 x 44 cm^2 using basket to mark the sampling area of the 10 times.

Population census and weighting.

Twenty - six ponds with the mean area 32 x 107.77 m^2 was randomly selected and conducted experiment. 10 replications per pond with area of 32 x 44 cm^2 using basket to mark the sampling area. When collecting the pond snails, used fishing net by pressing the sampling plot on the floor. Then, it was followed by putting the collected snails from the sampling plot to the outside basket. Each time, lifting the sieve up to the water was carried out for counting and weighting. Oscillating back and forth in a sieve was done to remove mud, dirt, and other particles in the grille off. Later, the collected snails were separated into dead and lives pond snail, random 100 snails were done along with the measurement of width and length. Totally 5,200 snails were determined to a body weight of live snail. The lives pond snail was collected by randomly 10 replications (200 snails/rep.) for determine water in body snail. Body weighting after remove mud and dirt adhere of shell were sun dried 20 minutes. There was pound shell for split water inside of body snail and sun dried 30 minutes.

Experiment 2 Study the nutritive value of pond snail.

Pond snails (*Filopaludina martensi*) obtained from Tilapia (planile) culture in Phan district, Chiang Rai province, Thailand. For this experiment three forms were used to find the nutritive value of the pond snail. The treatment includes: 1. snail meat (without shell), 2. whole snail (cooked) and 3. whole snail (Raw). The first two treatments were cooked separately for 2 minutes and 20 minutes in boiling water, respectively which was followed by mincing and drying by oven at 60 ^{o}C for 48 hours. The whole snail (raw) was minced and dried by oven at 60 ^{o}C for 48 hours. All parameter of pond snail samples were determined in triplicate.

Experiment 3 Investigate the levels of molasses and salt for fermentation of pond snail.

The fermented snail will be preserve using molasses and salt. Minced pond snail was mixed with molasses and salt in plastic bag (size: 8 x 12 inch) for fermentation, 300 g of sample /bag was incubated at ambient temperature and stirred 2 times per day at 8.30 AM and 4.30 PM. The molasses levels were used at 5.0, 7.5, 10.0, 12.5 and 15.0%, and salt were used at 3.25, 3.79, 4.33, 4.87 and 5.41%. Fermented pond snail was analyzed for pH, color, odor and nutritive values. The pH of sample was measured using pH meter of Waterproof model pHTestr 10. Nutrient analysis was determined by the proximate analysis according to AOAC (1990) methods. The energy was calculated in mega joules by multiplying the factors of fat, protein and carbohydrate with 37.7, 16.7 and 16.7%, respectively (Ekanayake *et al.*, 1999). The color and odor were determined every day at 8.30 AM. with a score for estimate quality of fermented pond snail: 1 = 7.5 – 10.0 (very good), 2 = 5.0 – 7.4 (good), 3 = 2.5 – 4.9 (pretty), and 4 = 0.0 – 2.4 (bad) by approved model of method detection plant fermentation which recommended by Department of Livestock Development (2005b). The experimental design was a completely randomized design (CRD) (Steel and Torrie, 1980), the treatments were 9 replications. The samples were determined 3 samples per time. The samples were determined for pH, color and odor at days 1 (after 8 hour fermented), 7 and 14 d. for molasses used and 7, 14 and 21 d. for the salt used.

Experiment 4 Determine the nutrient digestibility of diets in Thai native cock with feed containing various levels of pond snail meal.

The nutrient digestibility of pond snail was studied in different processing (0, 5% cooked, 10% cooked, 15% cooked, 5% raw,10% raw and 15% raw), using 28 twenty–five weeks of age Thai native cock, divided into 7 groups of 4 replications (one cock each). The nutritive values of experimental diets were referred to the recommendation of the Department of Livestock Development (2005b) (Table 15).

Which each cock was provided experimental diets for seven days as adapted to the environment in the individual cage. The cage was equipped with water nipple and feed troughs. Data was collected for 4 days with a plastic bag attached to the skin with sutures (Isshiki et al., 1989). Then chicken feed and feces were evaluated for proximate analysis following the method described by AOAC (1990). The data was analyzed to determine the digestibility of DM was calculated according to the following formula's (Schneider and Flatt, 1975):

Digestibility of dry matter

$$= \frac{\text{DM in feed intake - DM in feces}}{\text{DM in feed intake}} \times 100$$

Nutrient digestibility (%)

$$= 100\text{-}100\ [(\%\text{AIA feed} / \%\text{AIA feces}) \times (\%\text{Nutrient feces} / \%\text{Nutrient feed})]$$

Statistical analysis of the results

The data were analyzed according to variance in completely randomized design (Steel and Torrie, 1980). The treatment means showing significant differences were indicated by using Duncan's Multiple Range Test (Ducan, 1955). All statements of significance were based on the 0.05 level of probability.

Table 15 The composition of the experimental diets

Item	Control	Cooked snail meal (%)			Raw snail meal (%)		
	0%	5	10	15	5	10	15
Ground corn	79.12	75.40	70.28	65.11	74.60	70.39	64.63
Rice bran	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Soybean meal	5.65	4.55	2.78	2.18	5.35	2.67	2.46
Vegetable oil	0.50	0.50	1.25	1.50	0.50	1.25	1.50
Fish meal	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Snail meal	-	5.00	10.00	15.00	5.00	10.00	15.00
Limestone	0.90	2.00	2.75	3.01	2.00	2.75	3.21
Di-cal. (14% P)	1.25	-	-	-	-	-	-
Normal Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50
L- lysine	0.15	0.12	0.11	0.08	0.12	0.11	0.08
DL-Methionine	0.18	0.18	0.58	0.87	0.18	0.58	0.87
Premix [1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated chemical compositions (%)							
ME, (kcal/kg)	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00
CP	14.40	14.40	14.40	14.40	14.40	14.40	14.40
Ca	0.90	1.67	3.19	4.72	1.65	3.12	4.71
Avai P	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Met. + Cys	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Lys	0.98	0.98	0.98	0.98	0.98	0.98	0.98

Note [1/] Provided per kilogram of diet: vitamin A.11,925 IU; vitamin D_3 2,250 IU; vitamin E 9 IU; vitamin K_3 1.8 mg; vitamin B_{12} 0.02 mg; thiamine 1.1 mg; riboflavin 9 mg; pyridoxine 1.8

mg; biotin 0.1 mg; pantothenic acid 9.9 mg; niacin 38.25 mg; folic acid 0.9 mg; chorine 680 mg; iodine 1.2 mg; selenium 0.18 mg; iron 70 mg; copper 10 mg; zinc 60 mg and manganese 70 mg.

Experiment 5 The study on cooked pond snail meal (PSM) levels on productive performance of native chickens.

In the study, it was evaluated the effect of the levels of cooked pond snail meal (PSM) in diet on productive performance of starter and grower Thai native chicken. The experimental diet was selected from 4^{th} experiment on the best effects on the nutrient digestibility of chicken feed contained pond snail. One day - old Thai native chickens (Pradu Hangdum) were obtained from poultry farm of Maejo University. At 7 d of age, 144 mixed sex chicks were randomly assigned into 6 treatments with 4 replicates of 6 birds each. The experimental diets were: 0, 3.66, 7.39, 10.95, 14.60 and 18.25% cooked pond snail meal. They were calculated for substitute as fish meal at 0, 25, 50, 75 and 100%, respectively. Diets were 2 stages (1-6 and 7-16 weeks of age). All diets had iso-nitrogenic and iso-caloric. Nutrient composition of diets was followed as the Department of Livestock Development (2005b) (Table 16 and 17). The pens area was 2.5 m^2 and exposed to light 24 hours a day with *ad libitum* feed and water. Experimental period was conducted for 15 weeks, the data were analyzed as a Completely Randomized Design by ANOVA and using SPSS version 13.0 (SPSS, 2004.). Significant differences among treatments were indicated by using Duncan's new multiple range tests. The effects of increasing PSM and control diets were partitioned into linear, quadratic, cubic and quartic using polynomial trend analysis. A significance level of P<0.05 was used. At the 15^{th} weeks (end of experiment) one male bird per pen (4 birds/group) was randomly selected for determine carcass weight and small intestine (duodenum, jejunum and ileum) weigh and length following by Tarachai (2001). Chickens were euthanized by decapitation. This experiment was perform according to ethical principles and guidelines for the use of animals (National Research Council of Thailand, 1999)

Data recording will be done as follow:

1. Weighting and recording the body weight of chicken every week.

2. Recording the feed intake of chicken every week.

3. Weighting and recording carcasses weight and observation of intestine at the 16 week of age.

4. Recording on the mortality of chicken.

Statistical analysis

The data were analyzed according to variance in completely randomized design (Steel and Torrie, 1980). The treatment means showing significant differences were indicated by using Duncan's Multiple Range Test (Ducan, 1955). All statements of significance were based on the 0.05 level of probability.

Table 16 The experimental diets for 1 – 6 weeks of age

Ingredient (%)	Levels of cooked pond snail in diet (%)					
	0	3.66	7.39	10.95	14.60	18.25
	Fish meal substitution levels (%)					
	0	25	50	75	100	125
Ground corn	66.41	62.34	57.62	53.38	48.48	44.39
Rice bran	6.00	6.00	6.00	6.00	6.00	6.00
Soybean meal	21.68	22.29	22.97	23.85	24.47	23.84
Fish meal	4.00	3.00	2.00	1.00	0.00	0.00
Snail meal	0.00	3.66	7.39	10.95	14.60	18.25
Limestone	0.84	0.00	0.00	0.00	0.00	0.00
Vegetable oil	0.00	1.13	2.45	3.70	4.86	5.89
Di-cal. (14%P)	0.32	0.80	0.75	0.72	0.70	0.70
Normal salt	0.50	0.50	0.50	0.05	0.50	0.50
L- lysine	0.00	0.01	0.02	0.03	0.04	0.05

Table 16 (Continued)

Ingredient (%)	Levels of cooked pond snail in diet (%)					
	0	3.66	7.39	10.95	14.60	18.25
	Fish meal substitution levels (%)					
	0	25	50	75	100	125
DL-Methionine	0.00	0.02	0.05	0.07	0.10	0.13
Premix [1/]	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated chemical compositions (%)						
ME, kcal/kg	2,900.00	2,900.00	2,900.00	2,900.00	2,900.00	2,900.00
CP	18.00	18.00	18.00	18.00	18.00	18.00
Ca	0.80	1.68	2.67	3.80	4.86	5.89
Avai- P	0.44	0.44	0.44	0.44	0.44	0.44
Met + Cys	0.70	0.70	0.70	0.70	0.70	0.70
Lys	0.98	0.98	0.98	0.98	0.98	0.98

Note [1/] Provided per kilogram of diet: vitamin A 11,925 IU; vitamin D_3 2,250 IU; vitamin E 9 IU; vitamin K_3 1.8 mg; vitamin B_{12} 0.02 mg; thiamin 1.1 mg; riboflavin 9 mg; pyridoxine 1.8 mg; biotin 0.1 mg; pantothenic acid 9.9 mg; niacin 38.25 mg; folic acid 0.9 mg; chorine 680 mg; iodine 1.2 mg; selenium 0.18 mg; iron 70 mg; copper 10 mg; zinc 60 mg and manganese 70 mg.

Table 17 The experimental diets for 7 – 16 weeks of age

Ingredient (%)	Levels of cooked pond snail in diet (%)					
	0	3.66	7.39	10.95	14.60	18.25
	Fish meal substitution levels (%)					
	0	25	50	75	100	125
Ground corn	74.92	70.39	65.58	61.08	56.38	51.96
Rice bran	6.00	6.00	6.00	6.00	6.00	6.00
Soybean meal	12.38	13.07	13.78	14.46	15.16	14.54
Fish meal	4.00	3.00	2.00	1.00	0.00	0.00
Snail meal	0.00	3.66	7.39	10.95	14.60	18.25
Limestone	0.18	0.00	0.00	0.00	0.00	0.00
Vegetable oil	0.00	1.25	2.59	3.85	5.16	6.58
Di-cal. (14%P)	1.77	1.85	1.85	1.80	1.80	1.75
Normal salt	0.50	0.50	0.50	0.50	0.50	0.50
L- lysine	0.00	0.00	0.01	0.03	0.04	0.04
DL-Methionine	0.00	0.03	0.05	0.08	0.11	0.13
Premix [1/]	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated chemical compositions (%)						
ME, kcal/kg	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00
CP	14.40	14.40	14.40	14.40	14.40	14.40
Ca	0.85	1.88	2.97	4.00	5.07	6.18
Avai- P	0.53	0.53	0.53	0.53	0.53	0.53
Met + Cys	0.63	0.63	0.63	0.63	0.63	0.63
Lys	0.75	0.75	0.75	0.75	0.75	0.75

Note [1/] Provided per kilogram of diet: vitamin A 11,925 IU; vitamin D_3 2,250 IU; vitamin E 9 IU; vitamin K_3 1.8 mg; vitamin B_{12} 0.02 mg; thiamin 1.1 mg; riboflavin 9 mg; pyridoxine 1.8 mg; biotin 0.1 mg; pantothenic acid 9.9 mg;

niacin 38.25 mg; folic acid 0.9 mg; chorine 680 mg; iodine 1.2 mg; selenium 0.18 mg; iron 70 mg; copper 10 mg; zinc 60 mg and manganese 70 mg.

Experiment 6 The effects of pond snails meal on productive performance of Thainative laying hen.

Laying hens, Diets and Open housing: A total of 25 weeks-old thirty Thai native pullet having an average live weight of 1,709.83±67.45 g were selected and assigned into six treatment groups with 5 replication of 1 hen each. The experimental diets were used the cooked pond snail meal as follows: 0, 3.66, 7.39, 10.95, 14.60 and 18.25%, respectively. The composition and nutrients of the experimental diet was show in table 18. All diets had iso-nitrogenic and iso-caloric. The nutrient of dietary treatments base on recommended by The Department of Livestock Development (2005b). All birds were maintained in individual laying cages in open housing. An experiment was carried out at the poultry farm and laboratory, Faculty of Animal Science and Technology, Maejo University. Daily, each hen was with *ad libitum* feed and water. Light was provided by natural. Experimental period was 26 - 72 weeks of age (322 days)

Egg quality: Eggs were collected and counted every day. Egg production and feed consumption for each replication were recorded weekly for the entire study. Egg from each group was collected weekly to measure egg quality, criteria such as shell-breaking strength, shell thickness, shell ratio, albumen ratio, yolk ratio, yolk color and haugh unit. Egg weight was recorded by using an electronic digital balance. The shell- breaking strength was measured using an eggshell strength meter (Fuljihira Industry Co., Ltd.). The eggs were broken onto a metal plate and the height of the albumen was measured by the distance between the metal plate and the electrode placed on top of the thick. Then, the weight of the albumin, egg yolk, and eggshell were measured using an electronic digital balance. Shell thickness was a mean value of measurements at three locations on the egg (air cell, equator and sharp end) measured by a dial thickness gauge (Peacook, Tokyo, Japan). Yolk color was measured visually by using the Roche Yolk Color Fan (Roche Ltd., Besel, Switzerland).

The value of the shell ratio, albumen ratio and haugh unit were calculated for each individual egg using the following formula:

$$\text{Shell ratio} = \frac{\text{Shell weight} \times 100}{\text{Egg weight}}$$

$$\text{Yolk ratio} = \frac{\text{Yolk weight} \times 100}{\text{Egg weight}}$$

$$\text{Haugh unit} = 100 \log (H - 1.7\ W^{0.35} + 7.6)$$

H = observed height of the albumen in millimeters

W = weight of egg in grams

Haugh (1937; Houndonougbo et al., 2009) according to Feeding and laying performances (feed intake, feed conversion ratio, rate of egg and Body weight change), egg quality and economics of feeding (feed cost and economic feed Efficiency) were evaluated. Haugh units and feed efficiency were calculated.

Statistical analysis: The data were analyzed according to variance in completely randomized design (Steel and Torrie, 1980). The treatment means showing significant differences were indicated by using Duncan's Multiple Range Test (Ducan, 1955). All statement of significance were based on the 0.05 level of probability.

Table 18 The experimental diets of Thai native laying hens

Ingredient (%)	Levels of cooked pond snail in diet (%)					
	0	3.66	7.39	10.95	14.60	18.25
	Fish meal substitution levels (%)					
	0	250	50	75	100	125
Ground corn	49.63	55.97	57.80	60.46	56.73	53.88
Rice bran	10.00	10.00	10.00	10.00	10.00	10.00
Soybean meal	19.46	17.82	17.34	16.71	17.72	16.88
Fish meal	4.00	3.00	2.00	1.00	0.00	0.00
Snail meal	0.00	3.66	7.39	10.95	14.6	18.25
Limestone	5.00	3.45	1.48	0.00	0.00	0.00
Vegetable oil	5.72	3.02	3.20	0.08	0.11	0.06
Di-cal (14%P)	5.44	2.30	0.00	0.00	0.00	0.00
Normal salt	0.50	0.50	0.50	0.50	0.50	0.50
L- lysine	0.00	0.00	0.00	0.00	0.01	0.05
DL-Methionine	0.00	0.03	0.04	0.05	0.08	0.11
Premix 1/	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated chemical compositions by determined. (%)						
ME, (kcal/kg)	2,900.00	2,900.00	2,900.00	2,900.00	2,900.00	2,900.00
Crude protein, %	16.00	16.00	16.00	16.00	16.00	16.00
Ca, %	3.00	3.00	3.00	3.52	4.60	5.72
Avai P., %	0.16	0.16	0.16	0.16	0.16	0.16
Met + Cys, %	0.61	0.61	0.61	0.61	0.61	0.61
Lys, %	0.71	0.71	0.71	0.71	0.71	0.71

Note 1/ Provided per kilogram of diet: vitamin A 11,925 IU; vitamin D_3 2,250 IU; vitamin E 9 IU; vitamin K_3 1.8 mg; vitamin B_{12} 0.02 mg; thiamine 1.1 mg; riboflavin 9 mg; pyridoxine 1.8 mg; biotin 0.1 mg; pantothenic acid 9.9 mg; niacin 38.25 mg; folic acid 0.9 mg; chorine 680 mg; iodine 1.2 mg; selenium 0.18 mg; iron 70 mg; copper 10 mg; zinc 60 mg and manganese 70 mg.

CHAPTER 4

RESULTS AND DISCUSSION

Experiment 1 The study on population density of pond snail (*Filopaludina martensi*) in fish (Nile Tilapia) pond

The study on population density of pond snail (*Filopaludina martensi*) in fish (*Nile Tilapia*) pond, it revealed that the live snail population from 26 ponds average to 226.53±81.44 snail/m^2 with weight of 3.49±0.88 g/snail and 98.16±48.84 snail/m^2 for dead pond snails, average length of body 2.68±0.35 cm and width of body snail 1.76±0.21 cm as shown in Table 19. Snail population was very high density in the fish (*Nile tilapia*) culture. Because of in fish culture has appropriate ecology and the food is completed due to the mixed system of swine raising with the fish culture has fed 2 time /day, running water was 2 times /month. But, there is low weight due to have young snail more than adult snail. However, we found that live snail has a great number of baby snail in sample area. But population density of pond snail has higher than pond snail in another area. Chantima *et al*., (2013) reported that pond snail (*Filopaludina martensi*) in pond, rice paddy, irrigation canal, steam and river in Chaing Mai, Thailand was investigated in 6 districts found 212 snails per sampling 550 times (infected/examined). And when compare population density with snail species Natyani (2015) reported that snail (*Filopaludina martensi*) has the highest in canal in front of Siam Commercial Bank in Chiang Mai University in summer 2007.

Table 19 Investigation of pond snail (*Filopaludina martensi*) population

Items	Contents
Number of pond	26
Pond area (m^2)	6,964.10±206.47
Water depth for collected snails (m)	0.55±0.13
Number of pond snail (snail /m^2)	
- Live snail	226.53±81.44
- Shell (dead snail)	98.16±48.84
- Total	324.68±105.20
Body weight of live snail (g)	3.49±0.88
Length of body snail (cm)	2.68±0.35
Width of body snail (cm)	1.76±0.21
Water in shell, %	32.01±3.41

Experiment 2 To study the nutritive value of pond snail.

It was found that pond snail meat has the clearly higher CP (65.58%) and EE (6.31%) than cooked and raw whole pond snail but snail meat has lower CF (0.50%), ash (3.32%) and calcium (2.24%) because of pond snail has high ration of shell. However, when compared between cooked whole snail with raw whole snail found that raw whole snail was higher nutritive value than cooked snail as shown in Table 20. It was, found that crude protein of pond snail meat was higher than golden snail meat (60.90% CP, David and Kompaing, 1981), snail (*Limicoloria aurora*) meat (51.4% CP, Anthony *et al*., 1995), Africa giant snail (*Acbatina fulica*) meat (60% CP, El-Deek *et al*., 2002) and snail (*Pila globosa*) meat (52.40% CP, Kedar *et al.,* 2013). Therefore, the meat of pond snail has crude protein similar to fish meal. Moreover, pond snail meat meal has calcium and phosphorus closely with meat of golden snail meal (2.0% Ca and 0.84% P, David and Kompaing, 1981). Likewise, the whole cooked and dried pond snail has crude protein (16.38 and 16.94%, respectively) higher than whole golden snail (16.10% CP, David and Kompaing, 1981).

Table 20 Nutrients composition of pond snail (proximate composition: g/100 g DM)

Nutrients (%)	Meat snail meal	Whole snail meal (cooked)	Whole snail meal (dried)
Gross energy, kcal/kg	3,257±8.30	1,152±5.25	1,216±9.36
Crude protein	65.58±0.10	16.38±0.12	16.94±0.14
Ether extract	6.31±0.14	2.11±0.03	2.44±0.21
Crude fiber	0.50±0.12	1.46±0.27	1.53±0.15
Ash	3.32 ±0.04	46.08±0.02	45.84±0.05
NFE	24.29±1.84	33.97±0.54	33.25±0.85
Phosphorus	0.75±0.12	0.27±0.04	0.29±0.07
Calcium	2.24±0.06	30.89±0.45	30.73±0.32

Experiment 3 To study the levels of molasses and salt for fermentation of pond snail.

The fermented pond snail were preserved by molasses (Table 21) found that the pH, color and odor of molasses 15.0% has better than other treatments at 1 and 7 days of fermentation with has statistically significance (*P*<0.05). But pH at 14 day has not significant difference (*P*>0.05). However, all treatment at 14 days fermentation has pH, color and odor as a decreased quality. Such as pond snail fermentation with molasses has appropriate period at 7 day but not more than 14 day because of quality of color and odor become bad.

The fermented pond snail were preserved by salt (Table 22) found that the pH at all levels and fermentation periods has not significant difference (*P*>0.05). Color and odor of 5.41% salt has better than other treatments at 7 and 21 days of pond snail fermentation because of the fermented pond snail had the lowest pH. However, all treatment at 21 days fermentation has pH increased become bad quality. Such as fermentation with salt has appropriate period at 7-14 day.

Salt is effective as a preservative substance because it reduces the water activity of foods. The water activity of a food is the amount of unbound water available for microbial growth and chemical reactions. Salt's ability to decrease water activity is thought to be due to the ability of sodium and chloride ions to associate with water molecules (Fennema, 1996; Potter and Hotchkiss, 1995). Adding salt to foods can also cause microbial cells to undergo osmotic shock, resulting in the loss of water from the cell and thereby causing cell death or retarded growth (Davidson, 2001). It has also been suggested that for some microorganisms, salt may limit oxygen solubility, interfere with cellular enzymes, or force cells to expend energy to exclude sodium ions from the cell, all of which can reduce the rate of microorganism growth (Shelef and Seiter, 2005).

Table 21 The effects of molasses levels on quality of pond snail fermentation[1]

Period	Molasses levels (%)					C.V.
(day)	5.0	7.5	10.0	12.5	15.0	(%)
pH						
1	7.03^{A}	6.90^{AB}	6.83^{B}	6.67^{C}	6.60^{C}	2.57
7	7.00^{A}	6.93^{A}	6.57^{B}	6.57^{B}	5.90^{C}	6.44
14	7.37	7.30	7.30	7.40	7.53	1.86
Odor						
1	5.00	5.00	5.00	5.00	5.00	0.00
7	3.33	3.33	4.00	4.00	4.33	14.75
14	1.67	1.67	2.00	1.67	1.00	31.69
Color						
1	5.00	5.00	5.00	5.00	5.00	0.00
7	4.33^{B}	4.33^{B}	5.00^{A}	5.00^{A}	5.00^{A}	9.67
14	2.67	2.67	3.00	2.67	2.00	19.50
Total score (odor + color)						
1	10.00	10.00	10.00	10.00	10.00	
7	7.99	7.99	9.00	9.00	9.33	

Table 21 (Continued)

Period (day)	Molasses levels (%) 5.0	7.5	10.0	12.5	15.0	C.V. (%)
14	4.34	4.34	5.00	4.34	3.00	
Quality level						
1	1	1	1	1	1	
7	1	1	1	1	1	
14	3	3	2	3	3	

Note : $^{A-D}$ Values in the same row with a common superscript letter are significant difference (P<0.05)

[1] score for estimate quality levels of fermented snail: 1 = 7.5 – 10 ; very good, 2 = 5.0 – 7.4 ; good, 3 = 2.5 – 4.9; pretty, and 4 = 0.0 – 2.4; bad

Table 22 The effects of salt levels on quality of pond snail fermentation[1]

Period (day)	Salt levels (%) 3.25	3.79	4.33	4.87	5.41	C.V. (%)
pH						
7	6.90	6.83	6.87	6.77	6.73	1.20
14	7.13	7.10	7.10	6.90	6.93	1.40
21	7.53	7.40	7.37	7.37	7.33	0.70
Odor						
7	4.00	4.67	4.92	4.83	4.75	7.63
14	1.17^{D}	2.17^{C}	2.67^{B}	4.17^{A}	4.08^{A}	7.63
21	1.00^{C}	1.00^{C}	1.17^{C}	1.75^{C}	2.25^{A}	14.24
Color						
7	4.92	4.33	4.08	4.08	4.25	7.88
14	1.17^{C}	2.17^{B}	2.67^{B}	4.17^{B}	4.50^{B}	10.32

Table 22 (Continued)

Period (day)	Salt levels (%)					C.V. (%)
	3.25	3.79	4.33	4.87	5.41	
21	1.00^{B}	1.42^{B}	2.17^{A}	2.25^{A}	2.42^{A}	15.54
Total score (odor + color)						
7	8.92	9.00	9.00	8.92	9.00	
14	2.33	4.33	5.33	8.33	8.58	
21	2.00	2.42	3.33	4.00	4.67	
Quality level						
7	4	4	3	3	3	
14	1	1	1	1	1	
21	4	4	3	3	3	

Note: $^{A-D}$ Values in the same row with a common superscript letter are significant difference (P<0.05)

[1] score for estimate quality levels of fermented snail: 1 = 7.5 – 10 ; very good, 2 = 5.0 – 7.4 ; good, 3 = 2.5 – 4.9; pretty, and 4 = 0.0 – 2.4; bad

Experiment 4 To determine the nutrient digestibility of feed containing various levels pond snail meal in Thai native chickens.

The effects of feed including cooked pond snail meal and dried pond snail meal on nutrient digestibility of Thai native cocks. It was found that the digestibility of feed containing various levels pond snail meal in DM, CP, EE and NFE were not significant difference (P>0.05), however DM and NFE digestibility were the highest in 5% cooked pond snail feed. 10% cooked pond snail feed had the highest digestibility of CP and Ca and 15% dried pond snail feed had the highest EE digestibility. Digestibility of CF was found the highest in 10% dried pond snail feed and there was significant difference with 5, 10 and 15% cooked and 15% dried pond snails feed (Table 23). It was revealed that the ash digestibility was the highest in 15% cooked pond snail feed and there was a significant difference with 0, 5 and 10% cooked pond snail feed, 5 and 10% dried pond snail feed. Moreover the result revealed that 10% cooked pond snail feed had the highest Ca digestibility and significant difference with other treatments except 10% dried pond snail feed. 5% dried pond snail feed had the highest phosphorus and statistically significant difference with control and 15% dried pond snail feed ($P<0.05$). These results according to David and Kompiang (1981) reported that feeding meal prepared from boiled snail (*Achatina fulica*) 15 or 20 min in broiler fed 5 and 10% snail meal had performance better than 10 and 15% dried snail meal. However, boiling snail can remove slime and sterilize bacteria in body snail again. Mead (1961) reported that boiling in water is essential to get rid of toxic or unpalatable factors in the snails. In conclusion, the analysis for nutrients composition was suggested that snail meat is a source of protein. Boiling the snail was shown to be necessary to maximize digestibility and the levels at 5 and 10% cooked pond snail meal (CSM) in diets were high digestibility of NFE and CP, respectively. These results suggested that pond snail can be used as a new feed ingredient for poultry. Using of the whole snail would give a feed high in Ca but relatively low in CP. The snail shell is composed almost entirely of calcium carbonate, and separation of the bodies are therefore necessary if a high protein feedstuff is seek.

Table 23 The effects of feed including pond snail meal and dried pond snail meal in diets on nutrient digestibility of Thai native cock

Treatment	Nutrients digestibility (% DM) of pond snail diets							
	DM	CP	EE	CF	Ash	NFE	Ca	P
0% (non-snails)	74.95	46.40	88.48	33.84^{A}	8.10^{C}	83.68	30.53^{C}	51.29^{C}
Cooked pond snail								
5%	77.16	47.64	89.66	25.20^{B}	16.14^{B}	90.03	36.31^{BC}	62.99^{A}
10%	71.32	52.98	91.49	18.61^{C}	12.95^{BC}	87.31	58.76^{A}	59.55^{B}
15%	69.25	47.60	89.66	18.19^{C}	32.83^{A}	79.13	39.74^{B}	63.64^{A}
Dried pond snail								
5%	76.81	46.13	85.18	32.46^{A}	16.02^{B}	85.32	22.98^{D}	64.52^{A}
10%	74.95	45.55	91.98	35.38^{A}	14.85^{B}	80.74	43.40^{A}	60.14^{AB}
15%	71.42	44.00	92.43	27.75^{B}	30.88^{A}	84.58	30.53^{C}	58.69^{B}
SEM	4.22	5.89	3.87	8.94	5.85	6.78	11.21	3.84
C.V. (%)	0.82	0.90	3.76	5.66	17.52	2.27	17.59	4.79

Note: $^{A-C}$ Values in the same row with a common superscript letter are significant difference (P<0.05)

Experiment 5 The study on cooked pond snail meal on productive performanceof Thai native chickens (TNC).

Growth performance

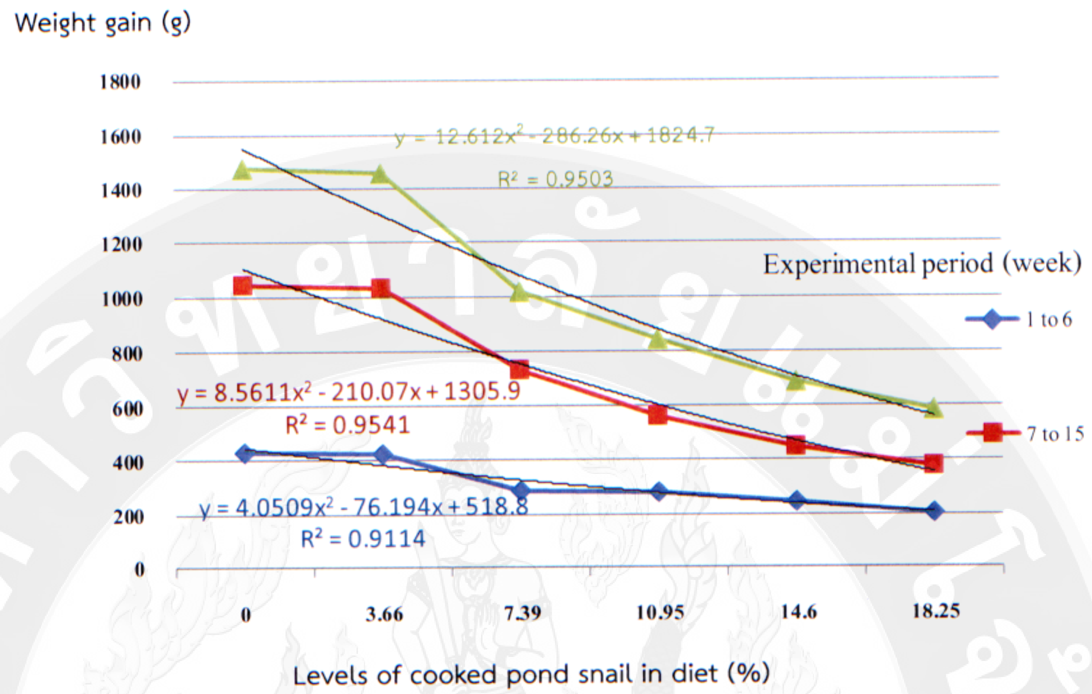
The growth performance of TNC conducted 15 weeks was investigated. The result was shown in Table 24. It was found that TNC at 1-6 week of experimental period were compered all treatments group, chicken fed 3.66% pond snail meal had weight gain and FCR, which were significant better than chicken fed 7.39, 10.95, 14.60 and 18.25% ($P < 0.05$) and weight gain showed a negative curvilinear to increasing levels of pond snail meal (Figure 10; R^2 = 0.9114), FCR showed a negative curvilinear to increasing levels of pond snail meal (Figure 12; R^2 = 0.5955). Which TNC at 7-15 week of experimental period the chicken fed 3.66% pond snail meal had weight gain, feed intake and FCR was significant better than chicken fed 7.39, 10.95, 14.60 and 18.25% pond snail meal but not significant difference ($P > 0.05$) weight gain showed a negative curvilinear to increasing levels of pond snail meal (Figure 10; R^2 = 0.9541), feed intake showed a negative curvilinear to increasing levels of pond snail meal (Figure 11; R^2 = 0.1391) and FCR showed a negative curvilinear to increasing levels of pond snail meal (Figure 12; R^2 = 0.9693). However, overall period (1 - 15 week) was found that poor growth performance was observed at weight gain (Figure 10; R^2 = 0.9503), feed intake (Figure 11; R^2 = 0.4209), FCR (Figure 12; R^2 = 0.9915), and mortality (Table 25), it were considerably reduced when chicken fed 7.39, 10.95, 14.60 and 18.25% pond snail meal ($P < 0.05$) compared 3.66% CSM and control group. According to David and Kompiang (1981) reported that broiler chicken fed 20, 25 and 28.6% African giant snail meal (*Acbatina fulica* Bowdich) has decreased performance but be opposite Elmslie (1982) showed that flesh of snail meal replacing fishmeal up to 15% of the diet had no negative effect on growth of broiler chicken but supplementing 20% or more snail meal (flesh) to diets decreased growth of broilers. Nevertheless, mortality was fond in TNC fed diets contained at high levels (14.60 and 18.25% pond snail meal) could be as according to the high Ca intake or balance of Ca with P in experiment al diets. In causing at first we observed to leg abnormalities in chickens up to 3 week of experimental period in TNC fed diets especially contained 18.2% pond snail meal. Leg abnormalities in growing chicken have many causes. The mineral content of the diet, especially Ca and P, can influence the incidence of valgus deformation and dyschondroplasia. Nelson *et al.* (1990), Ewing *et al.* (1995) and El-Deek et al. (2002) reported that dietary imbalance of Ca and P was shown to decrease broiler performance. In addition Nelson et al. (1990) indicated that high levels of P in causing leg abnormalities or wider Ca : P ratio. Furthermore, Jacob *et al*. (1998) cautioned that young birds should not be fed high Ca diets because Ca : P ratio will be unbalance which results in high morbidity and mortality. Similarly, Adamu *et al.* (2012) found that Ca : P at the level 3.5 : 1 in broiler diets were high mortality. Which Edwards (1984) obtained decreases in the incidence of dyschondroplasia with increased levels of dietary P, which was attributed to wider Ca : P ratio at the higher levels of P.

Table 24 The effects of cooked pond snail levels on productive performance

Experimental period (week)	Pond snail meal (%)						SEM	P-value, Trend[1]			
	0	3.66	7.39	10.95	14.60	18.25		Linear	Quadratic	Cubic	Quartic
Weight gain											
1 - 6	430.28^{A}	428.70^{A}	287.95^{B}	282.22^{BC}	246.02^{BC}	206.17^{C}	21.27	0.000	0.268	0.473	0.010
7 - 15	1,047.08^{A}	1,032.20^{A}	732.79^{B}	562.56^{C}	447.43^{CD}	381.01^{D}	56.01	0.000	0.075	0.003	0.007
1 - 15	1,477.36^{A}	1,460.90^{A}	1,020.74^{B}	844.78^{C}	693.45^{CD}	587.18^{D}	76.00	0.000	0.059	0.008	0.002
Feed intake											
1 - 6	1,442.5	1,532.5	1,474.07	1,368.86	1,233.49	1,321.82	21.19	0.106	0.401	0.463	0.003
7 - 15	5,451.63^{BC}	6,060.35^{A}	4,970.12^{CD}	4,882.75^{D}	5,687.11^{AB}	5,318.27^{B}	112.53	0.119	0.035	0.111	0.000
1 - 15	6,894.13^{B}	7,592.85^{A}	6,444.19^{C}	6,251.61^{D}	6,920.6^{B}	6,640.09^{C}	67.41	0.031	0.004	0.021	0.000
Feed conversion ratio											
1 - 6	2.97^{A}	3.16^{A}	4.30^{B}	4.04^{B}	4.09^{B}	5.02^{C}	0.44	0.000	0.272	0.595	0.117
7 - 15	5.21^{A}	5.87^{A}	6.78^{AB}	8.68^{B}	12.71^{C}	13.96^{C}	0.76	0.000	0.035	0.679	0.393
1 - 15	4.50^{A}	5.01^{A}	5.99^{BC}	6.94^{C}	9.24^{D}	10.31^{E}	0.60	0.000	0.025	0.783	0.720

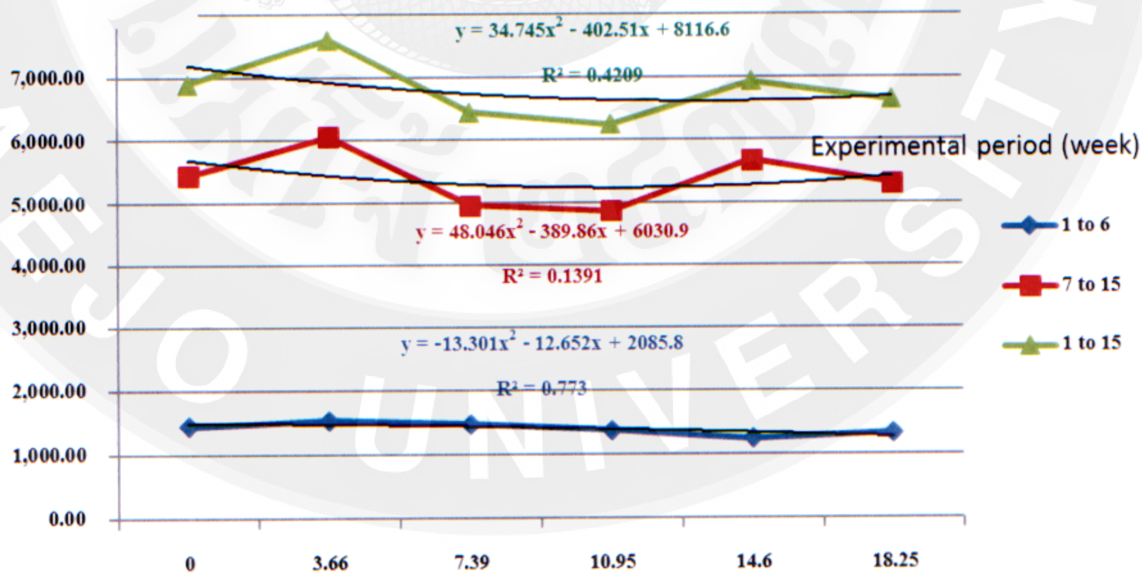
Note: $^{A-E}$ Values within row with different superscript are significantly difference (P<0.05)

[1] Refer to polynomial trend analys



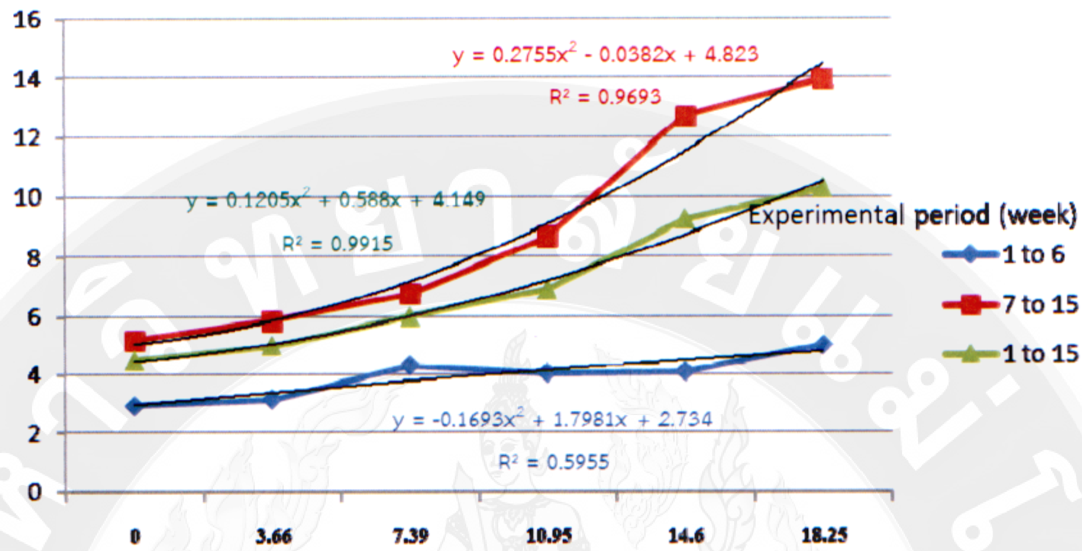
Y = Weight gain (g) X= Levels of cooked pond snail in diet (%)

Figure 10 The effects of cooked pond snail levels on weight gain



Y = Feed Intake (g) X= Levels of cooked pond snail in diet (%)

Figure 11 The effects of cooked pond snail levels on feed intake



Y = Feed Intake (g)   X= Levels of cooked pond snail in diet (%)

Figure 12 The effects of cooked pond snail levels on feed conversion ratio

Table 25 The effects of cooked pond snail levels on mortality rate of Thai native chicken (%)

Experimental period (week)	Cooked pond snail (%)						CV
	0	3.66	7.39	10.95	14.60	18.25	(%)
1 - 3	0.00	0.00	0.00	0.00	0.00	16.67	2.52
4 - 6	0.00	0.00	0.00	0.00	16.67	25.00	6.44
1 - 6	0.00	0.00	0.00	0.00	16.67	41.67	5.75
7 - 10	0.00	0.00	0.00	8.33	16.67	25.00	9.67
11 - 15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7 - 15	0.00	0.00	0.00	8.33	16.67	25.00	1.86
1 - 15	0.00	0.00	0.00	8.33	33.33	66.67	6.75

Carcass quality

The carcass quality of TNC conducted at 15 weeks of experimental period was investigated. The result was shown in Table 26. It was found that chicken fed control (0% pond snail) had carcass quality of edible part (live weight, dressing, pectoralis major and pectoralis minor) significant better than other groups ($P < 0.05$), except chicken fed 3.66% pond snail meal ($P > 0.05$). But the carcass quality of non-edible part and small intestine were found that chicken fed high levels of pond snail had percentage of carcass was significant higher than chicken fed control and 3.66% pond snail meal ($P < 0.05$). Length of small intestine was not significant difference ($P > 0.05$). And besides, obviously seen increases percentage of the weight of heart and liver + gall bladder in chicken fed contained pond snail were increased. However, the chicken fed control and 3.66% pond snail meal had the best performance.

Table 26 The effects of cooked pond snail levels on carcass quality (% live weight)

Item (%)	Levels of cooked pond snail meal in diet (%)						SEM	CV (%)
	0	3.66	7.39	10.95	14.6	18.25		
Live weight (g)	1,692.50^{A}	1,553.75^{A}	1,156.50^{B}	947.75^{C}	888.25^{C}	775.75^{C}	55.92	9.56
Killed weight	94.83	93.08	91.02	90.54	91.36	89.61	1.32	2.64
Blood	5.16	6.91	8.98	9.46	8.63	10.38	1.21	29.40
Feather	3.67	3.04	2.64	3.29	4.87	5.37	0.70	36.99
Dressing	91.16^{A}	90.04^{AB}	88.38^{ABC}	87.24^{ABC}	86.49^{BC}	84.24^{C}	3.58	2.99
Wing	8.49	9.06	9.52	9.63	9.05	8.50	0.31	6.85
Pectoralis major	10.03^{A}	9.18^{A}	7.14^{B}	6.93^{B}	6.96^{B}	6.32^{B}	0.37	9.60
Pectoralis minor	3.54^{A}	3.52^{A}	2.68^{B}	2.59^{B}	2.37^{B}	2.28^{B}	0.21	14.56
Thighs	13.74^{A}	13.75^{A}	11.67^{BC}	12.32^{B}	11.21^{BC}	10.34^{C}	0.47	7.74
Drumsticks	10.87	11.10	10.82	11.92	11.07	9.81	10.16	10.42
Heart	0.53^{C}	0.56^{BC}	0.89^{AB}	0.73^{ABC}	0.93^{A}	0.96^{A}	0.11	28.09
Feet	4.09^{C}	4.62^{BC}	5.07^{ABC}	5.96^{A}	6.10^{A}	5.38^{AB}	0.36	13.80
Head + Neck	8.66	8.49	8.39	9.08	8.88	8.80	0.26	6.19
Proventriculus + gizzard	2.79^{A}	2.51^{AB}	2.38^{ABC}	2.69^{AB}	1.83^{C}	2.10^{BC}	0.19	16.25
Liver + gall bladder	1.80^{C}	2.00^{BC}	2.51^{AB}	2.70^{A}	2.79^{A}	3.09^{A}	0.16	13.09
Whole intestine	3.90	3.92	4.11	4.76	4.09	4.07	0.23	11.50
Duodenum	0.55^{B}	0.64^{AB}	0.72^{A}	0.74^{A}	0.74^{A}	0.79^{A}	4.99	14.34
Jejunum	1.11	1.14	1.32	1.45	1.16	1.22	8.57	13.78
Ileum	0.56	0.64	0.63	0.67	0.65	0.56	3.87	12.45
Length of small intestine (cm)								
Duodenum	23.75	25.87	23.75	24.50	25.00	21.95	1.63	13.56
Jejunum	45.75	49.25	45.00	48.00	45.12	39.25	2.92	12.86
Ileum	29.92	33.00	30.00	36.00	31.00	24.00	2.88	18.55

Note $^{A-C}$ Values within row with different superscription are significantly different ($P<0.05$)

Experiment 6 The effects of pond snails meal on productive performance of Thai native hen.

Production performance

The productive performance of Thai native laying hen (TNH) conducted for 46 weeks during 26-72 week of bird age was investigated. The result was show in Table 27. It was found that TNH age period at 26-72 week were compered all treatments group, they had feed intake, initial weight, final weight, body weight gain and egg weight were not significant difference (P>0.05). But egg production and FCR were significant difference (P<0.05). Thai native hen fed control (0% snail meal) and 3.66% CSM have egg production and FCR better than other groups. But egg production was not significance different with hen fed 3.66 and 14.60% snail meal and FCR was not significant difference with hen fed 3.66, 10.95 and 14.60% snail meal.

Therefore, utilization of pond snail meal at high levels was not effects for TNH. Which, contrast with the 5th experiment a large amounts of calcium in feed are high level of snail meal had effects on health and mortality in young TNH (1-16 week old). Which, Van Eekeren *et al.* (1999) reported that Ca: P ration in laying hen while up to 6: 1 did not affect egg production.

Table 27 Effect of cooked pond snail meal levels on productive performance of Thai native laying hen

Parameters	Levels of cooked pond snail meal diet (%)						SEM	CV
	0	3.66	7.39	10.95	14.60	18.25		(%)
Feed intake, (g/d)	143.43	142.22	136.54	134.22	138.66	137.82	1.03	10.47
Initial weight, g	1,778.85	1,789.25	1,766.32	1,785.24	1,804.95	1,759.84	3.54	7.58
Final weight, g	1,828.25	1,837.65	1,798.47	1,802.58	1,825.79	1,798.21	5.41	8.23
Egg production (%)	41.16^{A}	41.01^{A}	32.02^{B}	31.33^{B}	38.66^{AB}	32.83^{B}	6.03	17.12
Egg weight, g	48.13	45.83	47.66	49.18	46.24	45.96	1.39	6.60
FCR (Kg feed/ Kg egg)	7.24^{A}	7.57^{A}	8.95^{B}	8.71^{AB}	7.76^{A}	9.13^{B}	3.19	6.23
Body weight gain (g)	49.40	48.40	32.15	17.34	20.84	38.37	4.54	12.48

Note $^{A-B}$ Values within row with different superscript are significantly difference (P<0.05)

Egg quality

The egg quality of TNH conducted 322 day was investigated. The result was shown in Table 28. It was found that TNH had shape index, eggshell thickness, shell-breaking strength, albumin & yolk, yolk ration, albumen ration, eggshell, haugh unit and calcium of eggshell were not significant difference (P>0.05). And TNH in the control group had bright and phosphorus of eggshell more efficiently, into egg, than other group (P<0.05), accept TNH fed 3.66% snail meal was not significant (P>0.05). Furthermore, we revealed that yolk color of Thai native hen fed 3.66% snail meal diets was significant better than other groups (P<0.05), accept TNH fed 7.39 % snail meal. Although, the egg quality had criteria were not significant difference but data was recorded for TNH fed high percentage pond snail meal in diets were shown tendency better external egg quality and internal egg quality was not difference with control group. Therefore, the pond snail meal levels were no effects on egg quality of TNH.

Table 28 Effects of cooked pond snail meal levels on egg quality of Thai native laying hen[1]

Parameters	Cooked pond snail meal (%)						SEM	CV (%)
	0	3.66	7.39	10.95	14.60	18.25		
Shape index	0.76	0.77	0.76	0.76	0.75	0.75	24.04	5.12
Eggshell Thickness, mm	0.196	0.239	0.242	0.219	0.211	0.345	109.17	46.23
Shell-breaking strength, kg/ cm^2	4.42	4.67	4.42	4.98	4.52	4.89	12.48	12.48
Bright of eggshell	65.93^{A}	59.09^{AB}	52.44^{BC}	52.27^{BC}	46.53^{C}	44.63^{C}	18.87	18.87
Albumin & Yolk, %	89.36	88.79	88.63	88.5	87.63	87.30	11.85	11.25
Yolk color	6.10^{BC}	7.00^{A}	6.40^{AB}	5.10^{C}	5.30^{C}	5.40^{C}	10.52	10.52
Yolk ratio, %	33.38	33.34	33.14	33.25	32.98	32.75	5.68	7.18

Table 28 (Continued)

Parameters	Cooked pond snail meal (%)						SEM	CV (%)
	0	3.66	7.39	10.95	14.60	18.25		
Albumen ratio, %	55.28	55.41	55.51	55.20	55.34	55.64	12.58	5.12
Eggshell, %	11.34	11.25	11.35	11.55	11.68	11.61	7.89	10.78
Haugh Unit	89.84	90.11	90.02	91.04	90.36	90.16	32.51	23.05
Calcium of eggshell (%)	24.81	25.03	26.30	24.79	23.82	25.79	31.05	2.60
Phosphorus of eggshell (%)	0.12^{A}	0.11^{AB}	0.10^{B}	0.08^{C}	0.08^{C}	0.07^{C}	9.09	9.09

Note: $^{A-C}$ Values within row with different superscript are significantly difference (P<0.05)

[1] Data was average 26-72 weeks of age (46 weeks)

CHAPTER 5

CONCLUSIONS

Based on the results of this study, the following conclusions are drawn:

Population density of pond snail (*Filopaludina martensi*) from 26 fish (Nile Tilapia) ponds, it revealed that the population consisted live snail and dead snails (226.53 and 98.16 snails/m^2) with average body weight of 3.49 g, length of 2.68 cm and width of 1.76 cm. In order to preserve high population of pond snail, molasses and salt were used for snail fermentation. Fermentation with 15% molasses made significant better pH, color and odor at 7 days of fermentation while 4.87 and 5.41% salt fermented snails had better color and odor than other treatments at 7 and 14 days of fermentation.

According to the nutritive value of pond snail, It was found that meat pond snail had the clearly higher CP (65.58%) and EE (6.31%) but had lower CF (0.50%), ash (3.32%) and calcium (2.24%) than raw and cooked whole pond snail. Determination of nutrient digestibility of raw and cooked pond snail at levels of 0, 5, 10 and 15% of diet was studied and found that DM, CP, EE and NFE digestibilities were no difference. However, high CF digestibility was found in 0, 5 and 10% raw pond snails while high ash digestibility was found in 15% pond snails in both processing forms. Supplementation of 10% raw and cooked snail had high Ca digestibility while supplementation of 5% raw pond snail had the highest P digestibility.

For productive performance of starter and grower Thai native chicken, supplementation of 3.66% pond snail meal or replacement of 25% fish meal could be used without effects on live weight, weight gain, feed intake, feed conversion ratio, carcass quality. However, there were linearly increased in weight gain and decreased in FCR as levels of pond snail increased. Pond snail meal could be used up to 3.66% in diet of Thai native laying hen with no effect on feed intake, initial weight, final weight, body weight gain and egg quality.

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APPENDIX

APPENDIX I

RESEARCH TABLE

Appendix Table 1 The effects of cooked pond snail levels on weight gain. (g)

Experimental period (week)	Pond snail meal (%)						SEM	P-value, Trend[1]			
	0	3.66	7.39	10.95	14.60	18.25		Linear	Quadratic	Cubic	Quartic
7 day	56.17	55.96	54.58	56.54	55.71	56.92					
1	45.75^{A}	47.25^{A}	39.17^{AB}	35.67^{BC}	33.04^{BC}	29.37^{C}	1.54	0.000	0.821	0.262	0.166
2	64.12^{A}	67.54^{A}	43.25^{B}	42.96^{B}	45.67^{B}	39.75^{B}	2.00	0.000	0.061	0.447	0.002
3	76.42^{A}	78.95^{A}	50.04^{B}	55.88^{B}	49.92^{B}	34.69^{C}	3.62	0.000	0.931	0.687	0.014
4	64.12^{A}	67.54^{A}	43.25^{B}	42.96^{B}	45.67^{B}	39.75^{B}	5.10	0.000	0.443	0.682	0.004
5	87.08^{A}	82.16^{A}	49.21^{B}	45.35^{C}	36.66^{C}	24.33^{C}	5.71	0.000	0.466	0.841	0.237
6	92.79^{A}	85.25^{A}	63.04^{B}	59.40^{B}	35.07^{C}	38.28^{C}	4.98	0.000	0.431	0.247	0.636
7	92.21^{A}	109.93^{A}	49.04^{BC}	65.53^{B}	36.17^{CD}	27.39^{D}	6.57	0.000	0.843	0.104	0.008
8	113.75^{A}	107.16^{AB}	82.04^{BC}	75.50^{C}	58.52^{C}	53.86^{C}	5.93	0.000	0.691	0.609	0.788
9	131.04^{A}	148.41^{A}	87.16^{B}	62.91^{C}	58.67^{C}	42.66^{C}	8.67	0.000	0.477	0.012	0.002
10	131.37^{A}	116.83^{A}	90.12^{B}	61.97^{C}	45.15^{C}	46.69^{C}	7.78	0.000	0.202	0.120	0.959
11	121.92^{A}	107.54^{A}	89.04^{AB}	65.04^{BC}	51.16^{BC}	44.62^{C}	7.63	0.000	0.508	0.315	0.685
12	127.04^{A}	124.79^{A}	69.68^{B}	59.54^{B}	47.03^{B}	36.39^{B}	8.70	0.000	0.083	0.999	0.004

Appendix Table 1 (Continued)

Experimental period (week)	Pond snail meal (%)						SEM	P-value, Trend[1]			
	0	3.66	7.39	10.95	14.60	18.25		Linear	Quadratic	Cubic	Quartic
13	129.96^{A}	119.67^{AB}	96.96^{B}	57.03^{C}	49.25^{C}	46.56^{C}	8.04	0.000	0.292	0.057	0.856
14	103.50^{A}	92.75^{A}	77.58^{AB}	56.12^{BC}	48.94^{BC}	33.67^{C}	6.25	0.000	0.939	0.734	0.713
15	96.29^{AB}	105.12^{A}	91.17^{AB}	58.92^{BC}	52.54^{C}	49.17^{C}	6.41	0.001	0.715	0.118	0.684
1 - 3	186.29^{A}	193.75^{A}	132.45^{B}	134.51^{B}	128.62^{B}	103.81^{C}	7.38	0.000	0.436	0.705	0.004
4 - 6	243.99^{A}	234.95^{A}	155.50^{B}	147.71^{B}	117.40^{BC}	102.36^{C}	14.30	0.000	0.272	0.436	0.048
1 - 6	430.28^{A}	428.70^{A}	287.95^{B}	282.22^{BC}	246.02^{BC}	206.17^{C}	21.27	0.000	0.268	0.473	0.010
7 - 10	468.37^{A}	482.33^{A}	308.36^{B}	265.91^{B}	198.51^{C}	170.60^{C}	26.23	0.000	0.220	0.005	0.007
11 - 15	578.71^{A}	549.87^{A}	424.43^{B}	296.65^{C}	248.92^{C}	210.41^{C}	30.61	0.000	0.101	0.019	0.056
7 - 15	1047.08^{A}	1032.20^{A}	732.79^{B}	562.56^{C}	447.43^{CD}	381.01^{D}	56.01	0.000	0.075	0.003	0.007
1 - 15	1477.36^{A}	1460.90^{A}	1020.74^{B}	844.78^{C}	693.45^{CD}	587.18^{D}	76.00	0.000	0.059	0.008	0.002

Note: $^{A\text{-}b}$ Values within row with different superscript are significantly difference (P<0.05).

[1] Refer to polynomial trend analysis.

Appendix Table 2 The effects of cooked pond snail levels on feed intake. (g)

Experimental period (week)	Pond snail meal (%)						SEM	P-value, Trend[1]			
	0	3.66	7.39	10.95	14.60	18.25		Linear	Quadratic	Cubic	Quartic
1	132.92	121.25	145.08	138.54	123.75	146.04	3.59	0.344	0.843	0.523	0.020
2	174.72	197.92	198.87	166.46	173.33	171.45	5.74	0.320	0.429	0.146	0.635
3	205.58^{BC}	235.83^{A}	222.50^{AB}	199.37^{BC}	210.25^{BC}	184.54^{C}	5.12	0.016	0.084	0.118	0.183
4	260.00	277.71	259.58	245.00	225.83	237.16	8.46	0.002	0.106	0.724	0.590
5	288.96^{AB}	311.25^{A}	252.29^{BC}	220.62^{CD}	192.81^{D}	256.18^{BC}	10.17	0.001	0.045	0.002	0.826
6	380.32	388.54	395.75	398.87	307.52	326.45	11.26	0.102	0.102	0.356	0.752
7	463.13^{A}	470.16^{A}	410.62^{AB}	383.41^{B}	462.50^{A}	355.36^{B}	12.34	0.013	0.918	0.283	0.005
8	531.45^{B}	527.92^{B}	525.62^{B}	518.54^{B}	579.75^{B}	659.17^{A}	12.93	0.002	0.008	0.345	0.729
9	565.41	565.62	475.42	523.21	585.31	562.64	12.15	0.736	0.042	0.368	0.024
10	606.87	609.58	509.91	481.66	592.25	475.55	21.45	0.109	0.520	0.563	0.049
11	505.62	571.44	484.38	680.56	680.56	469.44	23.19	0.619	0.462	0.294	0.009
12	713.75^{B}	911.48^{A}	661.46^{B}	622.71^{B}	701.12^{B}	677.22^{B}	26.63	0.048	0.690	0.033	0.003
13	697.29^{AB}	837.08^{A}	701.46^{AB}	578.12^{B}	741.12^{AB}	740.97^{AB}	25.23	0.590	0.347	0.058	0.016

Appendix Table 2 (Continued)

Experimental period (week)	Pond snail meal (%)						SEM	P-value, Trend[1]			
	0	3.66	7.39	10.95	14.60	18.25		Linear	Quadratic	Cubic	Quartic
14	717.91^{B}	830.41^{A}	645.83^{B}	635.54^{B}	688.31^{B}	716.39^{B}	18.29	0.091	0.119	0.027	0.005
15	650.20^{AB}	736.66^{A}	555.42^{BC}	459.00^{C}	656.19^{AB}	661.53^{AB}	25.56	0.336	0.021	0.106	0.003
1 - 3	513.22	555.00	566.45	504.37	507.33	502.03	9.93	0.150	0.219	0.068	0.995
4 - 6	929.28	977.50	907.62	864.49	726.16	819.79	12.42	0.309	0.218	0.993	0.808
1 - 6	1,442.50	1,532.50	1,474.07	1,368.86	1,233.49	1,321.82	21.19	0.106	0.401	0.463	0.003
7 - 10	2,166.86^{A}	2,173.28^{A}	1,921.57^{C}	1,906.82^{C}	2,219.81^{A}	2,052.72^{B}	37.16	0.456	0.037	0.447	0.000
11 - 15	3,284.77^{BC}	3,887.07^{A}	3,048.55^{CD}	2,975.93^{D}	3,467.30^{AB}	3,265.55^{BC}	87.70	0.132	0.138	0.025	0.000
7 - 15	5,451.63^{BC}	6,060.35^{A}	4,970.12^{CD}	4,882.75^{D}	5,687.11^{AB}	5,318.27^{B}	112.53	0.119	0.035	0.111	0.000
1 - 15	6894.13^{B}	7592.85^{A}	6444.19^{C}	6251.61^{D}	6920.6^{B}	6640.09^{C}	67.41	0.031	0.004	0.021	0.000

Note: [A-C] Values within row with different superscript are significantly difference (P<0.05).

[1] Refer to polynomial trend analysis.

Appendix Table 3 The effects of cooked pond snail levels on feed conversion ratio.

Experimental period (week)	Pond snail meal (%)						SEM	P-value, Trend[1]			
	0	3.66	7.39	10.95	14.60	18.25		Linear	Quadratic	Cubic	Quartic
1	2.91^{AB}	2.57^{A}	3.70^{B}	3.88^{B}	3.75^{B}	4.97^{C}	0.18	0.000	0.306	0.806	0.006
2	2.72^{A}	2.93^{AB}	4.60^{C}	3.87^{AB}	3.80^{AB}	4.31^{C}	0.19	0.002	0.070	0.374	0.063
3	2.69^{A}	2.99^{AB}	4.45^{BC}	3.57^{AB}	4.21^{BC}	5.32^{C}	0.23	0.000	0.980	0.082	0.139
4	4.05^{A}	4.11^{A}	6.00^{C}	5.70^{B}	4.94^{AB}	5.97^{BC}	0.39	0.001	0.951	0.546	0.041
5	3.32^{A}	3.79^{A}	5.13^{A}	4.86^{A}	5.26^{A}	10.53^{B}	0.71	0.000	0.031	0.039	0.294
6	4.10^{A}	4.56^{A}	6.28^{B}	6.71^{B}	8.77^{C}	8.53^{C}	1.59	0.101	0.193	0.017	0.036
7	5.02^{A}	4.28^{A}	8.37^{B}	5.85^{AB}	12.79^{C}	12.97^{C}	0.81	0.000	0.050	0.420	0.475
8	4.67^{A}	4.93^{A}	6.41^{AB}	6.87^{B}	9.91^{C}	12.24^{D}	0.92	0.000	0.093	0.680	0.958
9	4.31^{A}	3.81^{A}	5.45^{B}	8.32^{C}	9.98^{C}	13.19^{D}	0.77	0.000	0.035	0.245	0.465
10	4.62^{A}	5.22^{A}	5.66^{A}	7.77^{A}	13.12^{B}	10.19^{B}	0.93	0.000	0.225	0.379	0.237
11	4.15^{A}	5.31^{A}	5.44^{A}	10.46^{B}	13.30^{C}	10.52^{B}	1.36	0.002	0.914	0.111	0.042
12	5.62^{A}	7.30^{A}	9.49^{AB}	10.46^{AB}	14.91^{B}	18.61^{C}	1.51	0.007	0.538	0.880	0.191
13	5.37^{A}	6.99^{A}	7.23^{A}	10.14^{AB}	15.05^{B}	15.91^{C}	1.55	0.001	0.236	0.791	0.369
14	6.94^{A}	8.95^{AB}	8.32^{AB}	11.32^{B}	14.06^{B}	21.28^{C}	1.73	0.000	0.041	0.157	0.693
15	6.75^{A}	7.01^{A}	6.09^{A}	7.79^{A}	12.49^{AB}	13.45^{B}	1.21	0.002	0.036	0.655	0.786
1 - 3	2.75	2.86	4.28	3.75	3.94	4.84	0.17	0.000	0.532	0.138	0.016

Appendix Table 3 (Continued)

Experimental period (week)	Pond snail meal (%)						SEM	P-value, Trend[1]			
	0	3.66	7.39	10.95	14.60	18.25		Linear	Quadratic	Cubic	Quartic
4 - 6	3.81^{A}	4.16^{A}	5.84^{B}	5.85^{B}	6.19^{B}	8.01^{C}	0.84	0.000	0.170	0.851	0.319
1 - 6	2.97^{A}	3.16^{A}	4.30^{B}	4.04^{B}	4.09^{B}	5.02^{C}	0.44	0.000	0.272	0.595	0.117
7 - 10	4.63^{A}	4.51^{A}	6.23^{B}	7.17^{B}	11.18^{C}	12.03^{C}	0.74	0.000	0.029	0.422	0.507
11 - 15	5.68^{A}	7.07^{A}	7.18^{A}	10.03^{AB}	13.93^{BC}	15.52^{C}	0.91	0.000	0.090	0.845	0.594
7 - 15	5.21^{A}	5.87^{A}	6.78^{AB}	8.68^{B}	12.71^{C}	13.96^{C}	0.76	0.000	0.035	0.679	0.393
1 - 15	4.50^{A}	5.01^{A}	5.99^{BC}	6.94^{C}	9.24^{D}	10.31^{E}	0.60	0.000	0.025	0.783	0.720

Note: $^{A-E}$ Values within row with different superscript are significantly difference (P<0.05).

[1] Refer to polynomial trend analysi

APPENDIX II

CURRICULUM VITAE

CURRICULUM VITAE

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